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Recommended Practice For Distribution System Records

THIS recommended practice for the keeping of water works distribution system records has been developed for application to the needs of both large and small utilities. The aims to be accomplished in either case are identical. The essential difference between the record system of a large utility and a small utility is in the mass of records necessary. A valve or a hydrant deserves an accurate record of its existence in a small system just as much as it does in a large system. The form necessary to carry the essential information in regard to a given valve, hydrant, or main extension need be no different because of the size of the system. Inasmuch as distribution systems grow in size, it is desirable that the record procedure of a small utility be capable of expansion to take care of any amount of physical growth. This recommended practice has been developed with that problem in mind.

There is no intention that all record systems should conform to the procedure here outlined. This recommended practice has evolved

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from a study of many successful record procedures now being used by different utilities. It may be considered as a composite procedure made up of the best part of several record keeping procedures which have had their practicality proven. The practice details have been simplified to the point that they may be considered as a minimum standard which will give the necessary records.

Where distribution system records are not kept at all, or where the records are in such shape that they may be considered worthless, this suggested practice system might well be adopted in its entirety. Where good distribution system records are kept, it is hoped that this work will offer suggestions or ideas which can be used to increase the value of those records.

This suggested practice is designed to meet the requirements of both municipally and privately owned water distribution systems. Upon analysis, there appears to be no valid reason why any differences should exist between a proper record for a privately owned utility and a municipally owned utility. Both types of utilities should keep records of physical assets and both should have available all records necessary to render water users and the community the best possible service. Since there are no inherent differences between the physical make-up of the distribution system or the services to be rendered under municipal or private ownership, there need be no essential differences in the procedures of keeping distribution system records.

The word "utility" as it appears in this practice is used in its general sense and applies to both municipally and privately owned water works utilities.

The aims of this practice are twofold: first, to provide permanent records of the physical assets of the water works which are represented by the distribution system structures; and second, to provide practical, systematic records necessary for the efficient operation of the distribution system.

A Permanent Record of Assets in the form of properly mapped and statistical records is as necessary as is a permanent, honest and detailed accounting of the financial expenditures. Actually, the fact that an expenditure is made and entered properly in the general books of the utility means little unless a corresponding entry can be and is made in the records of physical assets. The auditor's record and the engineer's record not only must balance in themselves, but each must balance with the other.

An example of the necessity for a complete property record is found where the rates of a municipal or private utility are based upon the value of the water works property. This value (rate base) is usually determined by an inventory and an appraisal of the physical property. The above-ground structures can easily be inspected and inventoried. The below-ground structures, which comprise the greater part of the value of the utility, can be inventoried only from the mapped and statistical records. Pipe and valves installed but not shown on the distribution system records can not be included in the inventory of the property. The money spent on unrecorded underground structures is lost as far as receiving a return upon that part of the investment is concerned.

A great deal of emphasis is laid upon honesty in the accounting of receipts and expenditures. Records are kept in sufficient detail to account for the last penny. Carelessly kept or inadequate records not only reflect doubt as to ability but are often considered as evidences of lack of integrity of men keeping such accounts. Periodically, outside accountants are brought in to audit the books, ascertaining that proper accounts have been kept.

Distribution system records are seldom audited, although improper record keeping may cost more money than the falsification of accounts. Valves are cut into mains because valves originally installed were "lost." Valves are found closed in important mains because no record was made that they opened right instead of left. Mains dead-ending near each other may not be tied in for years because the use of improper symbols or careless drafting made it appear that the mains were tied-in on the mapped records. Pressure and water quality problems caused by such an error may be difficult to solve.

The keeping of distribution system records is often considered as secondary to the other engineering work. When other work is not pressing the records will receive attention. This attitude is probably the primary cause of inadequate records and can be corrected only by a realization of the importance and necessity of accurate records of physical assets. It should be expected of the engineer, just as it is expected of the accountant, that he will keep an accurate and truthful record of his work.

Efficient operation of a distribution system requires that the superintendent or manager have before him an accurate picture of the system he operates. He must have a picture of the system as a whole

to be able to determine which areas are inadequately supplied and why, whether the mains in an area are capable of supplying the water which might be required to fight a major conflagration, where fire hydrants are improperly spaced, where trouble should be looked for when pressures are found to be sub-normal, and to determine the best routes for installing new feeder mains. This record may be termed the "comprehensive map."

Day to day operation of the distribution system requires other records. Plats showing in proper detail the locations and valving of existing mains are necessary to allow the economical connecting of new extensions. These plats should, if possible, show the locations of all mains in relation to lots they serve. All active and inactive service lines should be shown and properly identified with the consumers' account numbers. Fire hydrants should be shown and numbered. All other necessary operating information should be placed on these plats. The record may be termed the "sectional plat record."

The crews working in the field require still further records. They should have small sized plats showing the layout of the distribution mains. They should also have complete sets of valve measurements covering the districts in which they work if valuable time is to be saved in making valve closures. It will be found that field men often know the locations of valves which are not shown on the office records. Unless the field men have copies of the valve records, these "lost" valves can never be placed in the records. In small systems valve records are often found to be in the heads of only one or two men. By placing this knowledge in permanent record form the loss of such a man can be kept from being a major disaster to a water utility. The valve record is of great value.

Card and statistical records of information impossible to show in necessary detail on maps or plats are also required. These comprise: records of service line location, sizes and materials; valve records showing make, type and repairs made; hydrant records giving similar information; records of leaks which will allow the superintendent to know whether the proper materials are being correctly installed in the system and also to protect the utility in case of suits being filed because of damages from leaking mains.

The problem of keeping records for a small distribution system is simpler than for a large system, but may be much more difficult to solve. In a small town one man may have to do many other jobs

at the same time he endeavors to make and keep proper records. It is just as important that he does not try to keep too many records as it is to keep enough. The selection of a suitable minimum number of records, depending upon the size of the city or town, will be covered in a section near the end of this recommended practice.

Each utility should prepare a "standard practice" to apply to its own procedure of keeping distribution system records. All phases of record keeping should be enumerated and described so that any one in the organization can, by referring to the standard practice, know how to prepare, find or interpret any of the distribution system records. Copies of all forms, preferably filled out with typical information, should be included. The general form used in this recommended practice may be followed in the preparation of a "standard practice" for a specific utility. Only by assembling in systematic order all of the distribution system records can it be determined that proper records are being kept.

Mapped Records

As outlined in the introduction, the efficient operation of the water distribution system requires three primary mapped records: first, a comprehensive map which will picture the entire system; second, a mapped record at a larger scale and probably composed of sectional plats which will show in detail all items of the distribution system; and third, gate valve records to be used by field crews. Supplemental mapped records are often necessary, especially in the larger systems.

1. Comprehensive Map:

The function of this record is to show a clear picture of the entire water distribution system in diagrammatic layout. It is primarily an operating record of value to the superintendent and construction engineer. It should be drawn in such fashion as to indicate readily the areas adequately piped, the sections which suffer through lack of large mains, the places where short extensions will eliminate dead ends, where many fire hydrants are installed in congested districts, but where mains are inadequate to support them in case of a major conflagration. Secondarily, as a record of physical assets, it may be likened to a balance sheet which sums up the assets and liabilities of the distribution system. The detailed accounting is left to another record.

Since the primary aim of this record is a clear picture of the water main system, all distracting information should be omitted. Street or property lines should not be shown, because the mass of these lines will overshadow the lines depicting the mains, causing this vital record to become merely another city map. Items of secondary interest should be left out. Different width lines should be used for different main sizes so that the larger mains with greater carrying capacity will be easily discernible. At intersections it will sometimes be necessary to depart from scale to show diagrammatically the layout of connections.

The scale should be as large as possible, using a map preferably 42 inches wide. At 500 feet per inch, street names, mains and sizes, valves, hydrants, and other important structures can be shown for a system 20,000 feet wide. For systems up to 40,000 feet in width, the scale should be reduced to a minimum of 1,000 feet per inch—using the same width of map, 42 inches. The drafting work, when 800 or 1,000 feet per inch scales are used, must be very carefully done, if the record is to be usable. For systems wider than 40,000 feet, wider cloth may be used, or the map may be made in two or more sections 42 inches wide, using a scale of 600 or 800 feet per inch. If cloth wider than 42 inches is considered, it must be remembered that prints may cost more per square foot. It may also be necessary to send the tracings to one of the larger cities to have extra-width prints made. The definite advantage of having the map in one unbroken piece must be balanced against this probable increase in cost.

This map must be laid out on an accurate base of range or section lines, otherwise the insertion of new subdivisions and major extensions will be difficult. The ordinary commercial maps available in many cities should not be used unless they are carefully checked as to reliability. When an accurate map is found, photostatic enlargements or reductions should be made to furnish a base map at the desired scale. This photostatic work must be carefully done with good equipment, or distortion will result.

The actual record should be made in ink on heavy tracing cloth. Careful drafting should be done. Street names must be small and neat and should be placed so that they will not be in the way of future mains to be added to the map at a later date.

This record should be posted semi-annually or annually; or immediately after major extensions are added. Black line on white

paper prints should be made from the tracing cloth record. Ordinary blue prints are not as satisfactory as black line prints. The slight extra cost of the latter is more than justified by the increased clarity of the black line map.

New copies of this map should be furnished for use as wall maps to the superintendent, the maintenance department, the mayor or city manager or president, and to the fire engine houses.

Figure 1 shows a portion of a comprehensive map.

2. Sectional Plats:

This record should be considered as the complete mapped record of the distribution system structures. It is the detailed account of the distribution system assets. Since it must be at much larger scale (except in very small systems) than the comprehensive map, this record must usually be in sections, hence the designation.

For a small system, this record can well be at the scale of 50 feet per inch. For larger systems, the scale should vary from 50 feet per inch in the congested areas to 100 feet per inch in the residential areas. In rural areas a 200-foot scale is suitable.

A convenient sheet size is 25 by 30 inches. This size will allow showing a section 1,000 by 1,250 feet at 50 feet per inch or 2,000 by 2,500 feet at 100 feet per inch, with $2\frac{1}{2}$-inch margins on top and bottom, a 3-inch margin on the binding edge, and a 2-inch margin on the free end. Should the town be laid out on the basis of mile square sections, a more desirable sheet size might be 31 inches by 32 inches, allowing a section plat a half mile square at 100 feet per inch with margins of 2.3 inches on three sides and 3.3 inches on the binding edge. With this system of subdivision, care should be taken that the edges of the sections do not fall on the half mile apart streets, but fall in the centers of blocks, so that entire streets and their abutting lots will be wholly within the various sectional plats.

Margins at least two inches wide are desirable as it may be necessary to increase slightly the area of certain plats where the edges would ordinarily fall within the lines of streets or their abutting lots. Enlarged sections of certain areas may be desirable and can be shown in the wide margins.

There should be no over-lapping areas in this record. Each plat should butt up against the next. If over-lapping areas are used, it will be necessary to post records that fall in such areas on two plats and sometimes on four at the intersecting corners. Confusion and

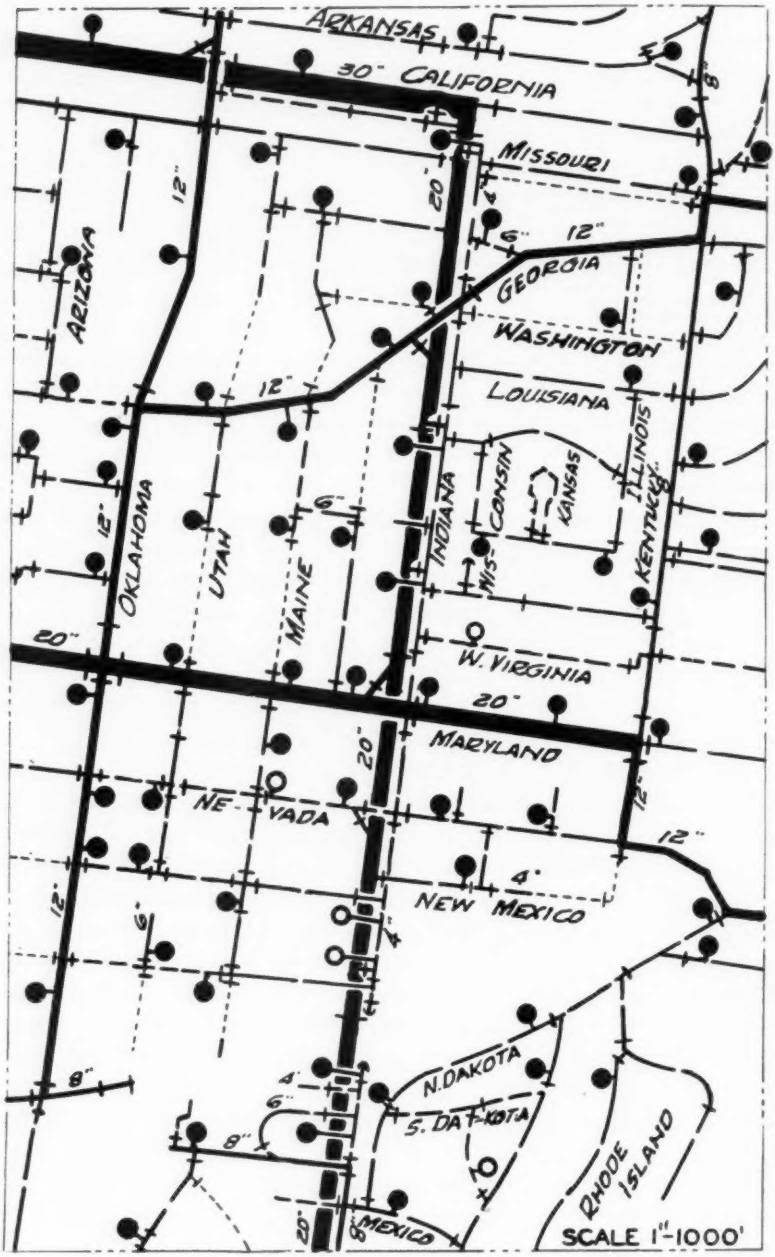


Fig. 1. Portion of Comprehensive Map

improperly platted records will result from the use of over-lapping areas at the edges of these plats.

The comprehensive map should be used as the base for the sectional plat subdivision. North-south and east-west coördinates should be drawn on a print of the comprehensive map corresponding to the size of 100-foot scale sectional plats. The spaces should be numbered 1, 2, 3, etc. from north to south and lettered A, B, C, etc. from east to west. The first letters and numbers should begin some distance outside the present limits of the distribution system to allow for growth in that direction. Where plats of 50-foot scale are necessary in congested areas, four plats will be necessary for one designation allowed by the number-letter index. These four plats would be designated by the index designation followed by a quadrant designation, for example, 6-F-N.E., 6-F-N.W., etc.

DATA RELATING TO FIGURE 1, COMPREHENSIVE MAP

Material: Original—heavy tracing cloth
Prints—black line preferred
Scale: Preferred scale—500 feet per inch
Maximum scale—1000 feet per inch

Items to be Shown on Map

1. Street names
2. Sizes of mains
3. Fire hydrants
4. Valves
5. Orientation arrow
6. Scale
7. Date last corrected

For large systems where the alphabet does not furnish enough symbols an alternate method of indexing is to use odd numbers to designate spaces from north to south, using even numbers to designate spaces from east to west. This latter system is used in Fig. 2.

The sectional plat record should be made in ink on heavy tracing cloth. New black line prints on white paper should be made annually or oftener for each sheet on which corrections or additions have been made. Additions and corrections to the engineering department copy of these plats should be made daily in red ink as the reports of work reach the engineering department. The original tracing cloth records should be corrected and additions posted periodically from the engineering department record. Whenever important corrections or additions are necessary during the year, the tracing of the sheet in question should be brought up to date and new prints made for each copy of the sectional plat record in use.

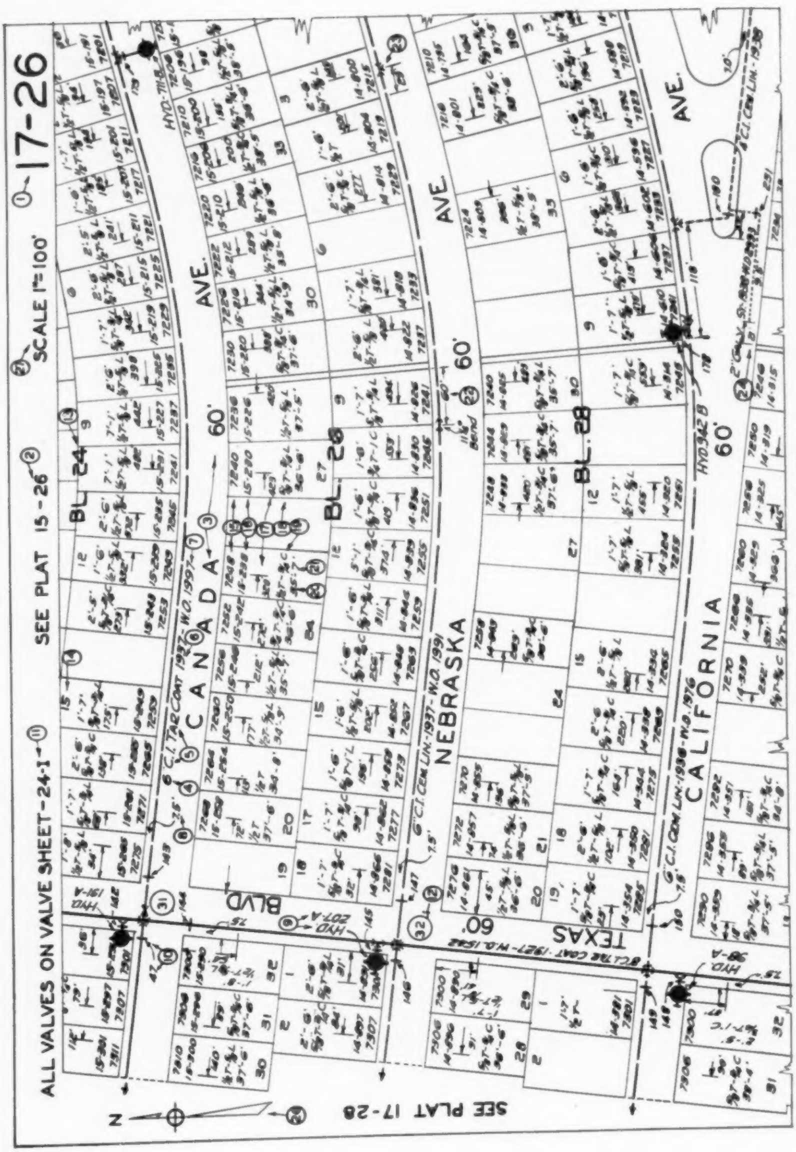


FIG. 2. Portion of Sectional Plat

The tracing cloth and print record is strongly recommended over the practice of keeping a single copy of this record on linen sheets. Due to the great amount of use this record receives, linen sheets have to be replaced at rather frequent intervals, and the records fade if colored inks are used or become illegible through ordinary wear. Also, this record is so valuable that it should be kept in duplicate. The tracings should be stored in a fireproof vault.

DATA RELATING TO FIGURE 2, SECTIONAL PLAT

Material:	Original—heavy tracing cloth Prints—black line preferred
Size of Plats:	20 by 25 inches or 26.4 by 26.4 inches, plus margins 2 to 3 inches wide.
Scale:	50 feet per inch in congested areas. 100 feet per inch in residential areas. 200 feet per inch in rural areas.
Index:	Coördinates; horizontal spaces lettered, vertical spaces numbered; or horizontal spaces even numbers and vertical spaces odd numbers.

Items to be Shown on Plats

1. Plat designation or number
2. Adjacent plat numbers
3. Street names and widths
4. Mains and sizes
5. Material of mains
6. Years mains were installed
7. Work orders of main installations
8. Distances from property line
9. Fire hydrants, numbers and classifications
10. Valves and numbers (omit valve sheet designation)
11. Valve sheet designation shown in margin
12. Intersection numbers (if valve intersection plats are used)
13. Block numbers
14. Lot numbers
15. House numbers
16. Water account numbers
17. Measurements to service lines
18. Sizes of taps
19. Sizes and materials of service lines
20. Distances, main to stop box
21. Distances, stop box to property line
22. Distances to angle points
23. Distances to fittings
24. Dead ends and measurements
25. Date last corrected
26. Orientation or north arrow
27. Scale

The map to be used as the basis of this plat record must be checked for accuracy. Tax assessment plats, insurance maps, subdivision plats or a city engineer's map may be available, but if they are not accurate, it will be better to start from scratch and produce an accurate base map at the proper scale.

On plats of 50 or 100 feet per inch, lot lines with block and lot numbers should be shown and it is desirable to place on each lot the house number, the water account number and the tap number. Measurements to locate the service line and stop box can be shown.

Valves and hydrants should be indicated on the sectional plats but dimensions to them may be omitted as this information should be kept in the valve and hydrant records, which will be described later.

It is desirable to indicate the hydrant numbers and the valve numbers on these sectional plats. If the plat and list method of keeping valve records is used, the page designation of the valve plat should show in the margin of each sectional plat. The valve numbers on each sectional plat will fall within one valve plat since the valve plats will normally cover at least four times the area of each sectional plat. Hence the valve number (otherwise normally prefixed by the valve plat designation) only should be placed on the sectional plat where a valve is shown.

Fittings should be indicated on this record by using proper symbols. Distances from intersecting street lines will allow the finding of these items in the field. This is especially true where tees and stubs are inserted for future use as they will not show on any other readily accessible record.

Figure 2 shows a portion of a sectional plat.

3. Valve Record:

Valves play such an important part in the operation of a distribution system that a separate record of them is warranted. To be of greatest value, this record should be kept in a manner which will allow copies to be carried by the outside maintenance, construction and emergency crews. This record must show measurements from permanent reference points to each valve so that it may be readily located. The record should also give certain factual information about each valve, e.g., the direction to open, the number of turns to open, and if possible the make, and date installed.

Several satisfactory methods of keeping these valve records are now in use. This practice will, however, confine its recommendations to the "plat and list" method as the preferred method, but offering the "intersection sheet" method as an alternate method desirable in certain instances.

The selection of the type of valve record to be kept by any given utility should be based in large part upon the valve records which are

available. If none have been kept the plat and list method is recommended. If the measurements to valves are in terms of distances to property lines, curb, or sidewalk lines, the plat and list method is recommended. If the measurements are based on intersecting arcs referenced to houses, buildings, trees, or other fixed objects which are harder to describe than to sketch, then the intersection sheet method should be used.

(*a*) *Plat and List Method.* This method of showing valve information eliminates several of the shortcomings of the widely used intersection plat method, especially for larger systems. It can also be used in conjunction with the intersection plat method to show valves in suburban or rural areas where otherwise only one or two valves could be shown on an intersection plat.

Each plat shows a section of the distribution system at 500 feet per inch scale covering an area 4,000 by 5,000 feet on an 8 by 10 inch drawing on 10 by 14 inch sheets. This is the same area as shown on four of the 100-foot scale sectional plats described in the preceding section. On this plat are shown street names, mains with sizes indicated, valves with numbers, and hydrants. On an opposite

DATA RELATING TO FIGURES 3 AND 4, VALVE RECORD—PLAT AND LIST METHOD

Material:	Original—tracing cloth sheets Prints—black or blue line, thin paper
Scale:	500 feet per inch, except rural areas at 1000 feet per inch
Size of Record:	Plats, 8 by 10 inches on 10 by 14 inch sheets. Lists, on 10 by 14 inch sheets
Index:	Print of comprehensive map divided with vertical and horizontal coördinates. Spaces numbered 1, 2, 3, etc. from south to north; lettered A, B, C, etc. from east to west.

Items to be Shown

On Plat	*On List*
1. Plat sheet designation	1. Plat sheet designation
2. Adjacent sheet designations	2. Valve number
3. Street names	3. Principal street
4. Mains and sizes	4. Reference measurement
5. Material of mains	5. Intersecting street
6. Fire hydrants	6. Reference measurement
7. Valves and numbers	7. Size of valve
8. Regulators, etc.	8. Make of valve
9. Orientation arrow	9. Direction to open
10. Scale	10. Turns to operate
11. Date last corrected	11. Remarks

SHEET NO. 24 I

VALVE NO.	PRINCIPAL STREET	DISTANCE FT.	DISTANCE DIR.	DISTANCE REFERENCE	INTERSECTING STREET	DISTANCE FT.	DISTANCE DIR.	DISTANCE REFERENCE	SIZE	MAKE	OPEN	TURNS	DATE SET	REMARKS
1	North Carolina	11	W	E.side E.walk	Pennsylvania	12	N	N.side N.walk	6	A.P.S.	L	13	5/22	
2	Pennsylvania	1½	S	N.R	Indiana	18	E	W. R	6	A.P.S.	L	16	7/38	Pat. Tap
3	Indiana	6½	E	W.R	New York	30½	N	N. R	20	Ren.	L	62	1931	
4	North Carolina	11	W	E.side E.walk	Colorado	9	N	N.side N.walk	2	A.P.S.	-	T.Hd.	9/12	
5	Colorado	12	N	S.side S.walk	North Carolina	3	E	of E.side E.walk	4	Cha.	L	9	5/22	
6	Colorado	22	S	N.side N.walk	North Carolina	11	W	E.side E.walk	2	Cha.	-	T.Hd.	9/12	
7	Colorado	22	S	N.side N.walk	North Carolina	12½	W	E.side E.walk	2	Cha.	-	T.Hd.	9/12	
8	New York	7¼	S	N.side N.walk	North Carolina	19½	W	E.R. priv. Rd.	2	P&C	-	T.Hd.	10/12	
9	West Virginia	7¾	S	N.side N.walk	Indiana	28½	E	W.R 7615	6	P&C	L	13	10/10	6' S.W. of Hydrant
10	New York	15¼	S	S.side S.walk	North Carolina	11¼	W	of E.side E.walk	2	Mue.	-	T.Hd.	2/13	
11	New York	15½	S	S.side S.walk	North Carolina	9¾	W	E.side E.walk	2	Mue.	-	T.Hd.	12/27	
12	North Carolina	13½	W	E.side E.walk	New York	10¼	N	S.side S.walk	2	Eddy	-	T.Hd.	9/12	
13	Colorado	22⅝	S	N.side N.walk	Florida	5½	W	E.side E.walk	4	Ohio	L	11	3/14	
14	Colorado	11	N	S.side S.walk	Florida	8¾	W	W.side W.walk	4	Ohio	L	12	3/14	
15	New York	16	S	N.R	Florida	14	W	W.R	6	Ren.	L	19½	3/35	Pat. Tap
16	New York	10½	S	S.side S.walk	Florida	9½	W	E.side E.walk	2	Ohio	-	T.Hd.	12/22	
17	Virginia	2¼	S	N.side N.walk	Florida	26¼	W	W.side W.walk	6	Fair.	L	13	5/15	
18	Virginia	8	N	S. side S.walk	North Carolina	3½	W	E.side walk bet. [illegible]	6	Fair.	L	13¼	11/23	
19	Tennessee	7⅝	E	W.side W.walk	New York	5½	N	N.side N.curb	6	Fair.	L	23	11/23	
20	Tennessee	7½	E	W.side W.walk	New York	6	N	N.side N.walk	6	M&H	L	18½	11/23	
21	New York	8	S	N.side N.walk	Tennessee	9½	E	E.side W.curb	6	M&H	L	22	11/23	
22	New York	6¾	S	N.side N.walk	Tennessee	12¾	W	W.side E.curb	6	M&H	L	22	11/23	
23	Tennessee	8	E	W.R	Pennsylvania	6	N	N.R	6	Lud.	L	23	4/25	In Vault
24	Pennsylvania	7	S	N.R	Tennessee	8	E	W.R	6	Lud.	L	23	4/25	
25	Tennessee	6	W	W.R	Pennsylvania	7	S	N.R	6	Lud.	L	23	5/25	
26	Virginia	1½	N	N.curb	Drive to 7171 Virginia	5	W	℄	6	Eddy	L	20	7/27	
27	Pennsylvania	10	N	S.R	Tennessee	12	E	W.R	6	Eddy	L	20	5/28	
28	New York	7	S	N.side N.walk	Massachussetts	49½	W	W.side W.walk	6	Vogt.	L	13	11/23	
29	Massachusetts	13	E	W.side W.walk	New York	26	N	N.side N.walk	6	Vogt.	L	13	11/23	
30	New York	20	N	S.curb of park	Massachusetts	8½	E	W.curb park	6	Ken.	L	13½	11/23	
31	Hawaii	9	E	W.curb	Maryland	47	N	S.curb	4	Ken.	L	12	12/14	
32	Private Drive	40	E	W.curb Hawaii	Maryland	4	S	S.curb	4	Darl	L	13	1/23	
33	Virginia	4½	S	S.curb	Hawaii	323	E	E.curb	4	Darl	L	13	1/23	
34	Pennsylvania	4½	S	S.side N.walk	North Carolina	5	E	E.edge E.walk	6	Crane	L	13½	9/31	
35	Pennsylvania	12	S	N.R	North Carolina	10	W	W.R	6	Crane	L	13½	9/31	
36	Pennsylvania	12	S	N.R	North Carolina	233	W	W.R	6	P&C.	L	21	3/32	
37	Maryland	36	N	S.side S.walk	P.D.Q. R.R.	25	E	E.rail	4	Crane	L	10	12/18	
38	Pennsylvania	9	N	S.R	Tennessee	290	E	E.R	6	Ren.	L	19½	10/35	1½' W. of Hydrant
39	New York	22	S	N.R	North Carolina	11	E	E.R	6	Ren.	L	19½	3/35	
40	New York	23	S	N.R	North Carolina	302	E	E.R	6	Ren.	L	19½	2/35	2' N. of Hydrant
41	Kentucky	18	E	W.R	New Jersey	16	S	S.R	8	A.P.S.	R	27	2/08	Note-Opens Right
42	Pennsylvania	12	S	N.R	Florida	417	W	W.R	6	Ren.	L	19½	5/35	
43	Pennsylvania	4½	S	S.edge N.walk	Florida	14	E	E.edge E.walk	6	Ren.	L	19½	5/35	
44	Pennsylvania	3½	N	N.edge N.walk	Florida	210	E	E.edge E.walk	6	Ren.	L	19½	5/35	
45	Virginia	28	S	S.edge N.walk	Hawaii	51	E	E.side house [illegible]	6	Ren.	L	19½	6/35	
46	Canada	7	S	N.R	Vermont	13	W	W.R	6	Cha.	L	18	10/24	
47	Canada	7½	S	N.R	Texas	7½	W	W.R	6	Cha.	L	18	2/27	
48	Indiana	5⅜	E	W.edge W.walk	Maryland	8½	N	N.edge N.walk	20	Ren.	L	62	1931	
49	Maryland	18½	S	S.edge N.walk	Indiana	1½	E	W.edge W.walk	12	Ren.	L	39	1931	By Pass
50	Maryland	12¾	S	N.edge N.walk	Indiana	51⅛	E	E.side E.walk	20	Ren.	L	62	1921	
51	Indiana	21¾	E	W.edge W.walk	Maryland	12½	S	S.edge S.walk	6	Cra.	L	13	4/09	
52	Indiana	12½	E	W.R	Pennsylvania	21	S	S.R	6	Cra.	L	14	4/09	By Pass

FIG. 3. Valve List

NOTE: Four additional valve lists are necessary to show all valves on Plat 24 I.

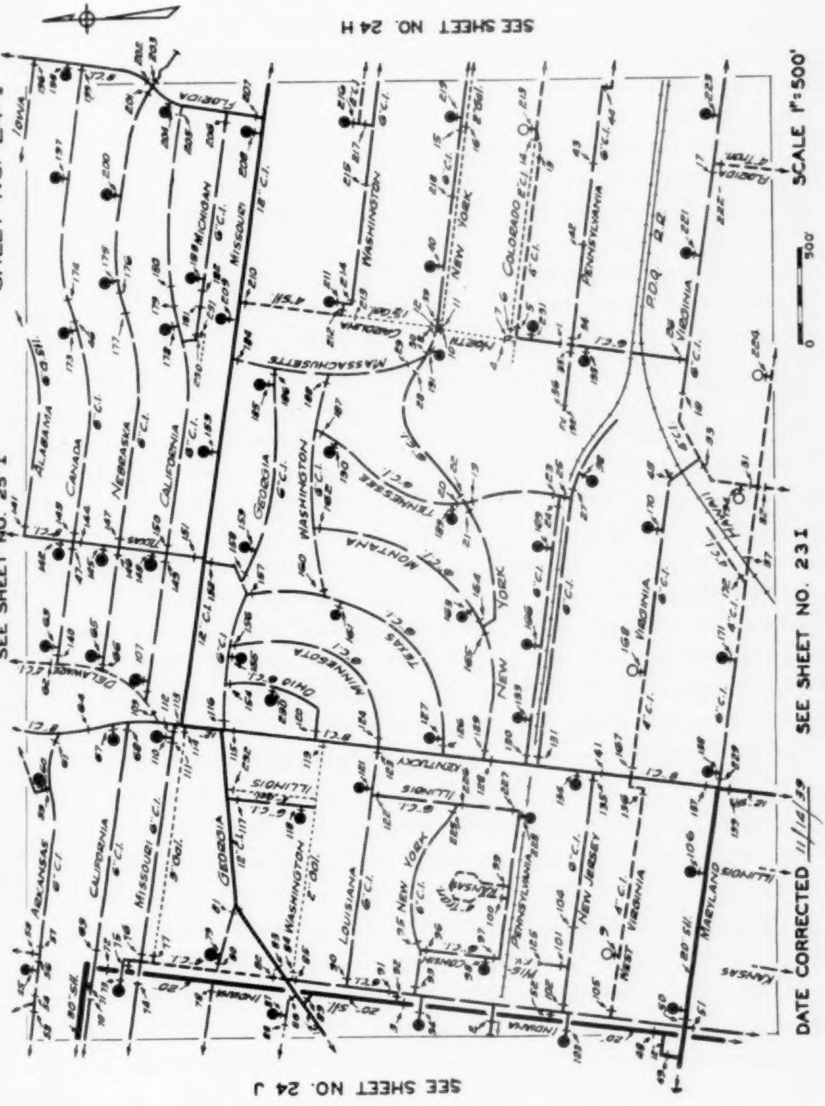


FIG. 4. Valve Plat

page or pages is shown the valve information: valve number, principal street with reference measurement to property line or street center line or curb, intersecting street with reference measurement to property line or center line or curb, size and make of valve, direction of operation and number of turns, date valve was installed, and remarks.

To show properly valves, etc. at intersections where the water main layout is complicated it will be necessary to include in the plat and list books sketches of these intersections suitably referenced to the plat showing the intersection.

The plats are indexed by the same or a similar coördinate system of numbers and letters as used on the sectional plats, and valves are designated by a suffix number, e.g. 7D1, 7D2, etc. The field indexes may be reduced copies of the comprehensive map or a city map on which the numbered and lettered space coördinates are shown. These field indexes do not have to be brought up to date as they are used only to show generally the area covered by any valve plat.

This system gives the field crews a record of all essential valve information and also shows how the mains are tied in. Its bulk is but a fraction of that of a corresponding intersection sheet record as the records of 250 valves can be shown with one plat and five sheets of listed information. Since the area of each 10 by 14 inch sheet is slightly less than one square foot, the cost of prints will usually be the same as that of 8½ by 11 inch prints of intersection sheets if the printing is done commercially. Prints should be black or blue line on thin white paper. This paper is available in 12-pound "air mail" weight.

Posting of corrections and extensions should be made daily in red ink on the engineering department copy of this record. Tracings should be corrected quarterly or oftener from the engineering department copy and new prints made for each copy of the record in use. Sheets should be slot punched for easy insertion in post binders.

Regarding *small systems,* where the comprehensive map of the system can be made at a 300- or 400-foot scale without requiring cloth more than 42 inches wide, the valve numbers can be shown on the comprehensive map, obviating the necessity of preparing sectional valve plats. At this large scale, the insertion of the valve numbers will not materially hurt the value of that record.

Figure 3 shows a valve list sheet and Figure 4 shows a valve plat.

(b) *Intersection Sheet Method:* This system requires the drawing of intersection plats on which mains, valves, hydrants, etc., are shown. These plats are at such scale that dimensions to permanent reference points, preferably property or street lines, can be given. The scale used should be 20 or 30 feet per inch. Valves between intersections cannot be shown to scale but dimensions from intersecting streets should be given to locate such out of scale items.

Indexing is by intersection numbers from one up for each sectional plat. Each intersection is therefore designated by the sectional plat number and letter followed by the intersection number, e.g., 7D17. Valves are designated by letter following the intersection designation, e.g., 7D17B. The index of intersection sheets to be carried in the field may be either a cross index of the streets in alphabetical order or may be a print of the comprehensive map which shows sectional plat areas and intersection designations thereon. If the latter method is followed, a separate cloth tracing should be made which shows the intersection designations as the great number of these designations will preclude the using of the comprehensive map for the real purpose for which it is intended. The comprehensive map index will also afford the field crews valuable information as to how the system is tied in. This duplicate tracing of the comprehensive map can be obtained through any blue printing firm at a cost which will be lower than that of retracing this map.

Intersection records should be kept on tracing cloth sheets, preferably $8\frac{1}{2}$ by 11 inches in size. Smaller sheets are often used with the result that complicated intersections can not be clearly shown at the small scale necessary. The prints should be black or blue line on thin paper with slot punchings in the binding margin. This type of punching enables new prints to be inserted readily in post binder covers.

At this point it should be pointed out that the intersection sheet record quickly becomes very bulky. In some large cities, this bulk has become so great that it is felt impossible to provide field crews with complete records. Some cities keep the intersection record only in the main office, thus defeating one of the prime reasons for the record. In outlying districts it is often impossible to show more than one valve on a sheet and in a system having 4,000 valves, as many as 2,000 intersection sheets may be required.

Figure 5 shows a sample intersection sheet.

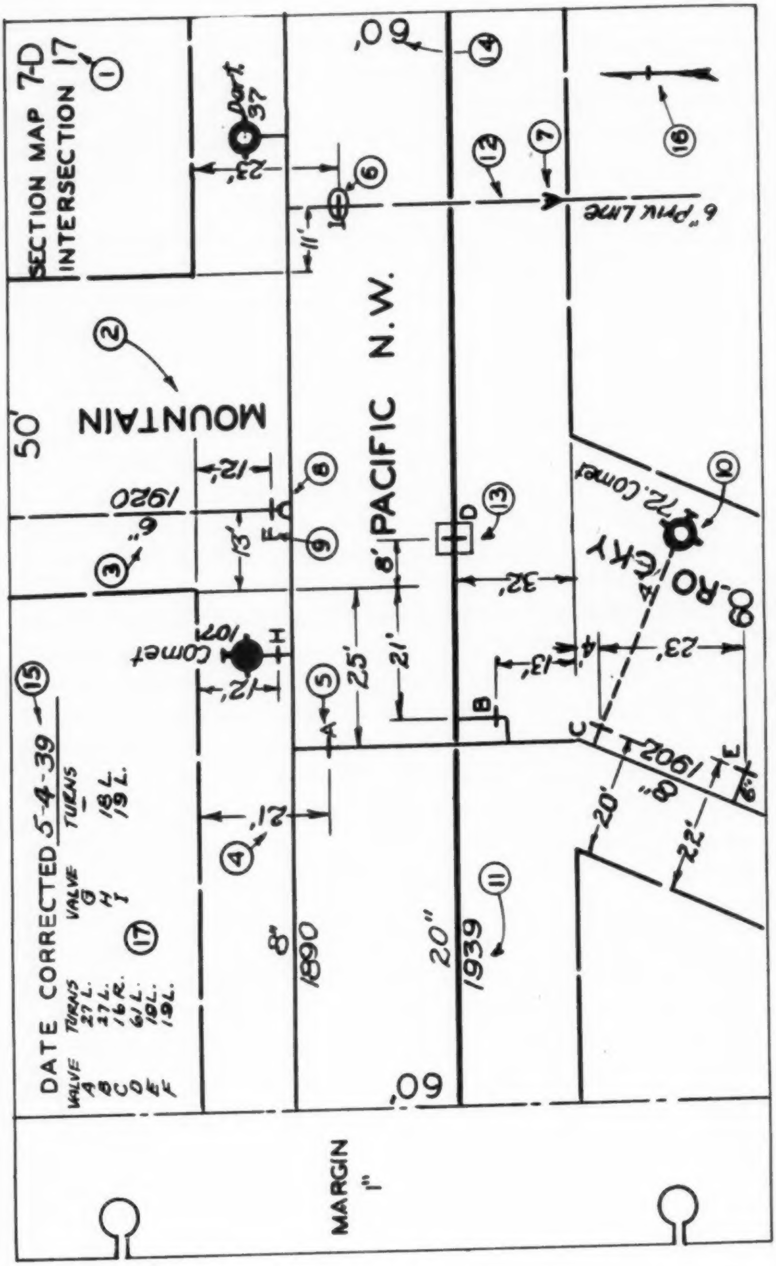


FIG. 5. Valve Intersection Plat

4. Supplemental Mapped Records:

(*a*) *Arterial Map.* For cities of 100,000 population or more, a comprehensive map at 2,000 or 3,000 feet per inch, showing only the primary distribution mains 8-inch or larger in size, is valuable for purposes of analysis. The mains should be given widths in proportion to their water carrying capacity.

(*b*) *Valve Closure Map.* To show weaknesses in the valving of a system, a closure district map should be made. By using different colored crayons or ink on a print of the comprehensive map, the sections of mains inside any valve closure area can be shown. Sections

DATA RELATING TO FIGURE 5, VALVE RECORD (ALTERNATE) INTERSECTION SHEET METHOD

Material:	Original—tracing cloth sheets. Prints—black or blue line on thin paper.
Scale:	Largest possible on 8½ by 11 inch sheet with proper margins.
Index:	Sectional plat sheet designation followed by intersection number.
References:	Measurements from property lines, street center lines or other permanent features.

Items to be Shown

1. Section map designation and intersection number	10. Hydrants, make, type and number
2. Street names	11. Dates mains were laid
3. Sizes of mains in inches	12. Large service lines
4. Distances from property lines	13. Valve in vault
5. Gate valves	14. Width between street lines
6. Closed gate valves	15. Date last corrected
7. Check valves	16. Orientation arrow
8. Tapping sleeve and valve	17. Valve turns and direction to operate
9. Valve letter (A, B, C, etc.)	

of great length will be made readily discernible by this method and a program of proper valving can be adopted for future use.

(*c*) *Leak Survey District Map.* Where regular leak survey work is conducted the valves to be closed and the areas isolated can be shown on a print of the comprehensive map. Pitometer taps should also be indicated.

(*d*) *Water Gradient Contour Map.* By taking nearly simultaneous pressure readings over the system during peak hour consumption, from which readings the water gradient is calculated, a valuable record can be made by placing these gradients on the comprehensive map and drawing in gradient contour lines. Areas suffering from excessive pressure drop will show up as valleys on this contour map.

(*e*) *Leak Frequency Map.* A mounted copy of the comprehensive map can be used to hold vari-colored push pins to indicate the occurrence of leaks. Each major type of leak is indicated by a pin of a chosen color. Points where soil conditions or electrolysis are bad, or where faulty workmanship or materials have been used will show up very effectively after a few years' use of this record.

Card Records

Certain of the distribution system records are difficult to keep as mapped records and are usually kept on cards. These are records of individual valves, hydrants, services, etc., where it is desirable to keep both location, descriptive and historical data for each unit.

No description of these card records is necessary in this text, since the sample cards show clearly the data which should be provided for. Space is allowed on each card for a short statement of the maintenance performed.

A natural inclination will be to show too little original information on these cards. The time required to list complete data will be only a minute or so longer than it takes to list incomplete data, while a few years later it will take hours to obtain data omitted on just a single item. Therefore, each card should have places provided for all the pertinent data. However, certain of the items shown on the cards may be omitted in specific cases; e.g., where hydrants or valves are all uniform in the direction of operation, there is no need for entering this item on each card.

Where card records are to be used by the larger water utilities, it is suggested that card forms such as those devised by the McBee Company or the International Business Machine Company be investigated. These card forms are suitable for punching various statistical data around the edges. Their use facilitates the obtaining of information from these cards with a minimum of clerical effort.

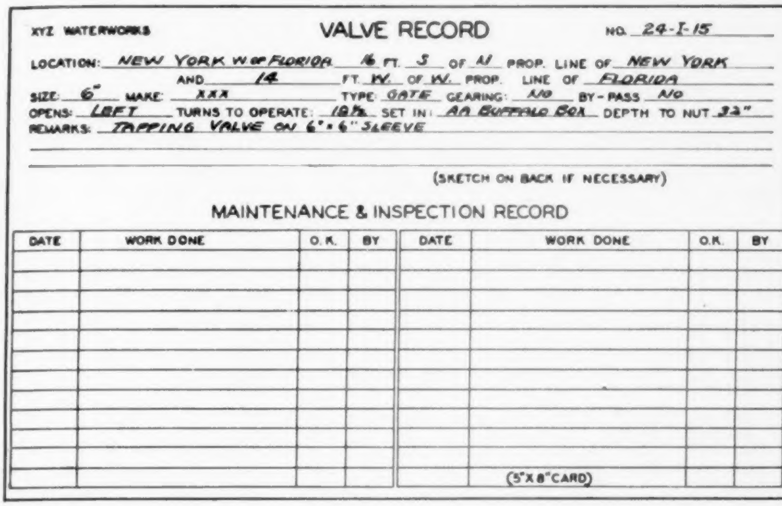
Should the utility be keeping a continuing property record of all structures and items, the card record for the operating department can be made at the same time the card for the accounting department is made. The cards are thin enough to allow both to be written at the same time, using carbon paper between them. The space on the operating department card used to show maintenance work performed can be used by the accounting department to show cost records.

It is suggested that 5 by 8 inch cards be used, since the necessary information can be placed on cards of this size without undue crowding or the omission of essential data. The data should be placed on the card with a typewriter or with neat printing.

The card records shown herewith are: Figure 6, a valve card; Figure 7, a fire hydrant card; and Figure 8, a consumer's service card.

Statistical Records

Summary records of property units are necessary in reporting construction progress and growth. These records should be posted



XYZ WATERWORKS VALVE RECORD NO. 24-I-15

LOCATION: NEW YORK W. OF FLORIDA 16 FT. S OF N PROP. LINE OF NEW YORK
AND 14 FT. W. OF W. PROP. LINE OF FLORIDA
SIZE 6" MAKE: XXX TYPE GATE GEARING: NO BY-PASS NO
OPENS: LEFT TURNS TO OPERATE: 19½ SET IN: AA BUFFALO BOX DEPTH TO NUT 32"
REMARKS: TAPPING VALVE ON 6"×6" SLEEVE

(SKETCH ON BACK IF NECESSARY)

MAINTENANCE & INSPECTION RECORD

DATE	WORK DONE	O.K.	BY	DATE	WORK DONE	O.K.	BY
					(5"x8" CARD)		

FIG. 6. Valve Card Record

monthly and should show in summary all of the important items comprising the distribution system structures.

1. Mains. The mileage of each size of mains should be summarized and totaled each month. The mains laid or retired during the month should be posted and totaled in feet. Should it be desirable to carry the totals forward as miles and fractions, the unit should be one-ten thousandth mile or approximately 6 inches.

2. Valves. The number of valves of each size should be summarized and totaled each month.

3. Hydrants. The number of fire hydrants of each size installed should be summarized and totaled each month. With the hydrants should also be listed the number and size of gate valves on hydrant

XYZ WATERWORKS

HYDRANT RECORD

NO. 191

LOCATION N.W. COR. CANADA AND TEXAS WORK ORDER NO. 1761
DATE SET 4-18-29 MAKE XXXX OUTLETS 2 $2\frac{1}{2}$" : 1 $4\frac{1}{2}$" : DEPTH OF BURY $4\frac{1}{2}$'
SIZE OF: BARREL 6" VALVE OPENING 4" HUB OPENING 6" HYDRANT OPENS LEFT
BRANCH: SIZE 6" LENGTH 19' CONNECTS TO 8" MAIN ON TEXAS WITH TAPPING SLEEVE
BRANCH VALVE: MAKE XXX OPENS LEFT TURNS 19 LOCATED 4 FT. E OF HYDRANT
ELEVATION 116' STATIC PRESS: NORMAL 78# PEAK HR. 66# RESID. PRESS. ONE $2\frac{1}{2}$ OPEN 34# CLASS A
REMARKS:
GUARD POSTS SET TO PROTECT HYDRANT

MAINTENANCE & INSPECTION RECORD

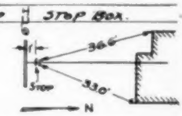
DATE	WORK DONE	O.K	BY	DATE	WORK DONE	O.K.	BY
					(5"X 8" CARD)		

FIG. 7. Hydrant Card Record

XYZ WATERWORKS

CONSUMER'S SERVICE RECORD

TAP NO. 35631
WORK ORDER NO. 5-1492.
ADDRESS 7273 NEBRASKA ACCT. NO. 14-858 DATE INSTALLED 9-28-39
LOCATION OF TAP N. SIDE OF 6" MAIN 156 FT. E OF E P.L. OF TEXAS AVE
MAIN 1' STOP BOX 6' PROP. LINE 25' BLDG. TOTAL LENGTH 32' FT.
SIZE CORP. 5/8" : SIZE SERVICE 1" : MATERIAL LEAD
CURB COCK 1" : STYLE INVERTED ROUNDWAY ; SET IN LOCK TOP STOP BOX.
REMARKS REPLACES OLD SERVICE.
OLD TAP #10091 DESTROYED



MAINTENANCE RECORD

DATE	FOREMAN	WORK PERFORMED
		(5"X 8" CARD)

FIG. 8. Service Card Record

branches and the length and size of branches. This record will indicate the total of items making up the portion of the distribution system rendering fire protection service exclusively.

4. Services. If services are installed to the property line or to the building by the utility, the monthly summary should show feet of each size of service pipe, number and size of corporation stops, curb stops, etc. If services are installed and owned by the householder the service record need be only a summary of the number added or abandoned during the month and the total.

The form of monthly summary record for the above parts of the distribution system should be similar to the suggested form for valves shown herewith.

Suggested Form of Monthly Summary Record

VALVES IN SERVICE

	size in inches							
	2	3	4	6	8	12	20	etc.
Units in Service, beginning of month	—	—	—	—	—	—	—	—
Units added during month	—	—	—	—	—	—	—	—
Sub-Total	—	—	—	—	—	—	—	—
Units retired during month	—	—	—	—	—	—	—	—
Total units in service, end of month	—	—	—	—	—	—	—	—

Since statistics regarding growth, construction progress, etc. lend themselves readily to graphical representation, it is suggested that graphical summary records be kept wherever possible in addition to the ordinary statistical records.

Summary records of operating and maintenance work are necessary for measuring the efficiency of the distribution department. Such summaries are generally included in the annual report of the water utility and are made from field reports of maintenance and inspection. The efficiency of operations can best be judged by comparing the cost per unit of maintenance work performed in one year with the costs found in another year. Suitable forms for field reports of maintenance work are presented in a later section.

Work Orders and Reports

In considering the end to be achieved, namely the securing of a complete record of the distribution system, it is necessary to set up an orderly procedure which will insure that all necessary informa-

XYZ WATER WORKS.
EXTENSION ORDER

On Maple Avenue Street
In FOREST GLEN Subdivision
City XYZ Sch. Dist. FOREST
Sewer Dist. FOREST Plat Sheet No. 17-M

PIPE LAID

Laid 211 ft. of 6" C.I. pipe
on MAPLE AVE.
from a point 13' S. OF S. P.L. OF NORTH DRIVE.
to a point 224' S. OF S. P.L. OF NORTH DRIVE.
Main lies 9 ft. E. OF W. P. OF MAPLE AVE.

TYPE OF EXCAVATION

Concrete — Sq. Ft. Tarvia 76 Sq. Ft.
Tunnels 19 Ft. Rock 100 Cu. Ft.

RETIREMENT

Retired 96 ft. of 2" GALV. Pipe
on MAPLE AVE.
from POINT 13' S. OF S. P. OF NORTH DRIVE.
to POINT 109' S. OF S. P. OF NORTH DRIVE.
Original Installation Date MARCH, 1916.

	Hour	Date
Job Started	10 A.M.	8-2-39
Job Finished	4 P.M.	8-3-39

Sterilized 8-3-39 By John Doe
By John Doe Foreman
Checked By J.McD. Engineer

TERMS OF EXTENSION Job No. P-715 Work Order No. 2871

DEPARTMENT EXTENSION:
Purpose: —

PROMOTER'S EXTENSION:
A. B. White contracted for 204 ft. of 6" pipe
on Maple Avenue from North Dr. South
to C/L Lot 6 Bl. 2 by contract dated 6-20-, 1939
at $ 1.35 per ft. $275.40 total.
Amt. paid $100. Date 6-20 1939. Balance $ 175.40, paid 7-15, 1939

MATERIAL USED ON MAIN

	Amt.	Size	Class	Lining	Joint	Make
Pipe	207'	6"	150	CEM.	SULPHUR	X-FOUNDRY
			Make	Ident. Marks	Turns To Open	
Valves Boxes and Stakes	1	6"	XXX	1938	19-L	
	1	A	VALVE BOX			
	1	2"	XX	I.B. FLUSH VALVE		
	1	193	VALVE BOX			
			Kind	Descrip.		
Fittings	2	6"	22½°	X-FDY	B.S. BENDS	
	1	6"×2"		X-FDY	TAPPED PLUG	
	1	2"	45°	GALV.	ST. ELL	
	1	2"×10"		GALV.	NIPPLE	
	1	2"×8'		GALV.	RISER PIPE	
Other Materials	60#	SULPHUR COMPOUND.				
	47½'	½" SQ. YARN.				
	2½'	⅜" " "				
	1 GAL.	KEROSENE				
	½ TON	2" MACADAM				

MATERIAL USED TRANSFERRING SERVICES

Amt.	Size	Description

Mileage Rec.	8-31-39	By G.G.
City Map	8/15/39	By A.A.
Plat Sheet	9-4-39	By C.B.
Comp. Map	9-30-39	By C.C.
Valve Plat.	8-4-39	A.A.
Credited S. H.	8-31-39	By H.J.R.

ORDER TO LAY PIPE

To John Doe Foreman Date July 16, 1939
You are hereby authorized to lay 204 ft. of 6" c. i. pipe on the west side of Maple Avenue from present dead end (12' s. of south property line of North Dr.) extending southwardly.

Replace 92 ft. of 2" Galv. Steel

XXX Do not salvage pipe
Signed R. B. Roe

(SKETCH ON REVERSE SIDE)

FIG. 9. Main Extension Order and Report

tion is returned by the field crews in intelligible form. The procedure known as the "work order" system has already received widespread adoption for the accounting of costs and a very slight modification or addition to the ordinary procedure will insure that complete records of construction work reach the record keeping department.

Distribution system records are customarily made up from information received in the form of field sketches showing every item of material installed. Another separate summary of materials obtained from issue and return tickets reaches the cost accounting department through the work order routine. In a small utility, the work order summary of materials should be checked against the field sketch to know that all items of material agree on both records. In large utilities where records and accounts are kept by different departments, a duplicate of the work order materials summary should be forwarded by the accounting department to the engineering records department for comparison with that department's record. Should any discrepancy exist, an investigation should be made immediately to insure rectification of the incorrect record. Only by making this comparison can the same list of materials be charged against the job and also be put into the distribution system records.

The materials accounting and work order system procedures will not be outlined here. These subjects have been adequately covered in Chapters 8 and 13 of the *Manual of Water Works Accounting*, published jointly by the Municipal Finance Officers Association and the American Water Works Association.

The form of report to be made of field work will vary with the procedures now used by any given utility and the capability of its men in the field. The simple forms shown hereafter have been found entirely satisfactory for use by the field crew foremen for reporting construction work. These are $8\frac{1}{2}$ by 11 inch sheets printed on one side. Instructions are given to the field crew foreman and provision is made for his reporting materials, measurements and other pertinent data. On the reverse side a sketch of property lines, existing mains, valves, etc. is made in ink by the engineering department. The proposed work is laid out in pencil, all pipe, valves, fittings, hydrants, etc. being shown by proper symbols. As the work proceeds, the foreman inserts all necessary dimensions and measurements, and makes corrections where the installation could not follow the original outline. Immediately after the job is finished and the field report received, the construction engineer or superintendent

should check the foreman's report and sketch to see that they are correct. The accounting department report on materials used should be received and checked with the field report before the job data are entered on the permanent mapped and statistical records.

Recorded { On Plat Sheet 7-3-39 B.B. / On Comp. Map 7-5-39 B.B.

XYZ WATER WORKS
FIRE HYDRANT SET ORDER

LOCATION

On N.S. of Cherry Rd.
about 300 ft. W. of Apple Drive

XYZ CITY (City) BROWN (Sch. Dist.)
Plat Sheet No. 19-S

REPORT

Set 6" inch SPIGOT END Fire Hydrant
299 ft. W. OF W. R. OF APPLE DR.
6.5 ft. S. OF N. R. OF CHERRY RD.
tied into 6 inch line on CHERRY RD.
Hydrant shutoff valve is:
299 ft. W of W P. L. of APPLE DR.
8.5 ft. S of N P. L. of CHERRY RD.
2.0 ft. S. of hydrant.

	Date	Hour
Job started	6-27-39	8:00 AM.
Job finished	6-27-39	3:30 P.M.

By John Roe (Foreman)
Initial Pressure 79#
Residual Pressure 21# Checked by J. McD. (Supervisor)
Pito Pressure
Flow 2500 G. P. M.

Hydrant was ordered set by XYZ CITY under Ordinance #3197
Date 6-21-, 19 39.
Hydrant No. 981
Account No. 310-5
Office Ticket No. 19763

Job No. F-435-G Work Order 2836

MATERIAL USED

Hydrant: Make and size 6" XXX
Number and diam. of outlets 1-4½"; 2-2½"
Length 4' BURY

	Amt.	Size	Description
Pipe	4'	6"	BELL PIPE. CEM. LINED.
Valves Boxes and Stakes	1	6"	XXX VALVE 1938
	1	A	VALVE BOX
Fittings	1	6"	TEE BSS
	1	6"	SOLID SLEEVE
Other Materials	60#		LEAD
	7'		½" YARN
	7'		3/8" "

Credited Store House: Date 6-29-, 1939. By HJR.

ORDER TO FOREMAN

To J. Doe, Foreman:
You are hereby authorized to set 6 inch Fire Hydrant on the N.Side of Cherry Rd. near P.D.Q. R.R. RIGHT OF WAY in XYZ CITY
Signed R. B. Roe.
Date June 22, 1939

FIG. 10. Hydrant Order and Report

A sample of a water main extension order and report form is shown as Figure 9 and a sample of a fire hydrant order and report form is shown as Figure 10.

Maintenance Records

While a utility can operate without keeping many records of maintenance work performed, it is usually necessary for the super-

intendent or manager to report the amount of maintenance work performed to justify the expenditures made under his supervision.

Sample sheets are presented for several of the maintenance operations. Where historical records are kept of valves, hydrants, services, etc., these operation reports should be transcribed to the individual historical cards before the reports are filed. These report sheets should be punched, and handled in the field in loose leaf note book covers.

Leak records are of vital importance in the long time operation of a distribution system. Such records allow the superintendent to know whether he is using proper materials in the system; whether certain mains are deteriorated to a point warranting replacement; and whether the causes of the breaks are electrolysis, corrosion, faulty materials, improper installation, outside agencies, water hammer, increased pressure, or some other factors. It is recommended that a leak map be used for a visual record of leaks. A copy of the comprehensive map mounted on wall board is suitable as a base map. Push pins are inserted at the locations of all leaks, various colors being used to indicate the various causes and types of leaks. The leak records also afford a positive and necessary record of the circumstances surrounding each leak. This information is essential to defend properly the utility against lawsuits for damages occurring from leaks, which suits may be filed months after a leak has occurred.

The maintenance report forms presented are:

Symbols

The need for some degree of standardization of symbols used on mapped distribution system records is desirable. Each mapped record tells a story which could be made clearer if the language used was based upon an alphabet familiar to a person endeavoring to read the record.

It is not desirable that there be a complete standardization of sym-

(5" X 8" SHEET)

VALVE MAINTENANCE REPORT

XYZ WATER WORKS VALVE NO. 24-I-47

LOCATION CANADA W. OF TEXAS

MEASUREMENTS: CHECKED O.K. ✓ MEASURED AS FOLLOWS:

____ FT. ____ OF ____ P.L. OF ____

____ FT. ____ OF ____ P.L. OF ____

VALVE: TURNS LEFT TO OPEN. NO. OF TURNS 19

FOUND PARTLY CLOSED OR 7 TURNS CLOSED ____

PACKING: O.K. – TIGHTENED – REPLACED YES

STEM: O.K. ✓ BENT OR BROKEN – REPLACED –

NUT: O.K. – MISSING YES REPLACED YES

GEARS: CONDITION NONE GREASED –

BOX ✓ OR VAULT ____ O.K ____ REPLACED ____

BURIED ____ IN. PROTRUDING ____ IN. ____

TOO CLOSE TO STEM YES RESET YES

COVER: MISSING YES BROKEN ____ REPLACED YES

WEDGED IN ____ TARRED OR GROUTED IN ____

ANY OTHER DEFECTS NONE

INSPECTED 9-27-39 BY J. JONES

DEFECTS CORRECTED 9-27-39 BY J. JONES

FIG. 11. Valve Maintenance Report

(8½" x 11" SHEET)

ROUTINE VALVE INSPECTION REPORT

VALVE PLAT	VALVE NO.	1 ST. OPERATION DIR.	TURNS	OPENED OR CLOSED	2 ND. OPERATION DIR.	TURNS	OPENED OR CLOSED	PACKING	BOX	MEASUREMENTS	REMARKS	OFFICE CHECK
24-I	23	R	22	closed	L	23	opened	O.K.	O.K.	O.K.		✓cm
"	24	R	16	closed	L	23	opened	O.K.	closed 3"	O.K.	Valve was partly closed.	✓cm
"	25	R	23	closed	L	23	opened	O.K.	O.K.	Bad	New measurements taken.	✓cm
"	26	R	20	closed	L	20	opened	O.K.	O.K.	O.K.		✓cm
"	27	L	20	opened	R	20	closed	O.K.	O.K.	O.K.	Valve left closed.	✓cm
"	28	R	30+	?				O.K.	O.K.	O.K.	Stem found broken.	✓cm
"	29	R	13	closed	L	13	opened	O.K.	O.K.	O.K.		✓cm
"	30	R	13	closed	L	13½	opened	Tightened	O.K.	O.K.		✓cm
"	31	R	12	closed	L	12	opened	O.K.	O.K.	O.K.		✓RZ
39-R	17	L	19	closed	R	19½	opened	O.K.	Lid Missing	Bad.	Lid Replaced New measurements taken	✓RZ
"	19	R	23	closed	L	23	opened	Bad	O.K.	O.K.	works hard - Stem bent should be replaced.	✓RZ
"	27	R	27	opened	Left this valve open.			O.K.	O.K.	O.K.	Operation [illegible] Change valve record.	✓RZ

XYZ WATER WORKS DATE 9-20-39 BY Jim Jones

FIG. 12. Routine Valve Inspection Report

NOTE: The first two columns routing the order of inspection are filled out in advance by the Engineering Dept. All repairs should be reported on form Fig. 11.

XYZ WATERWORKS

REPORT EVERY OPERATION

3" X 5" SHEET

VALVE OPERATION REPORT

VALVE PLAT 24-I VALVE NO. 15 DATE 8-26-39

PRINCIPAL ST. NEW YORK 12 FT. S. OF N. R.

INTERSECT. ST. FLORIDA 19 FT. W. OF W. Curb.

SIZE 6" MAKE XXXX OPENS L. TURNS 19½ DEPTH 32"

VALVE RECORD: INCORRECT ✓ CORRECT REMARKS: BOX WAS OFF CENTER - Realigned - Now O.K.

OFFICE CHECK 8-29-39. cm. OPER. BY John Smith

FIG. 13. Valve Operation Report

Instructions on this form:

1. Report every valve operation, except routine inspections.
2. Show plat and valve number where valve data are in record.
3. Fill out street data and measurements only if valve record is incorrect.
4. Indicate whether valve record is correct or incorrect.
5. Remarks—show work done or needed on valve or box, or other information.

(5" X 8" SHEET)

HYDRANT MAINTENANCE REPORT

XYZ WATER WORKS ______ HYDRANT NO. 191

LOCATION NEW YORK W. OF FLORIDA

CAPS: MISSING 1-2½" REPLACED YES GREASED YES

CHAINS: MISSING 1-2½ REPLACED YES FREED OTHERS ·

PAINT: O.K. NO REPAINTED CLASS A COLORS

OPER.NUT: O.K. ✓ GREASED YES REPLACED -

NOZZLES: O.K. - CAULKED 1-2½" REPLACED -

VALVE & SEAT: O.K. ✓ REPLACED -

PACKING: O.K. - TIGHTENED YES REPLACED -

DRAINAGE: O.K. NO CORRECTED BLEW OUT WITH PRESSURE

FLUSHED 25 MINUTES 1-2½" NOZZLE OPEN

PRESSURE: STATIC 69# RESIDUAL 36# FLOW 1010 G.P.M.

BRANCH VALVE: CONDITION O.K. BOX COVERED

RAISED 3".

ANY OTHER DEFECTS: STEM APPEARS BENT.

STEM REPLACED -

INSPECTED 9-8-39 BY Jno. Smith

DEFECTS CORRECTED 9-11-39 BY Jim Jones

FIG. 14. Hydrant Maintenance Report

bols between all utilities for all mapped records. The cost involved in changing existing records would outweigh any advantages which could be obtained. These symbols are offered as a guide to be followed where it is advantageous to do so.

Symbols should, if possible, bear an obvious resemblance to the features which they represent. There should be no confusion

(8½" x 11" SHEET)

FIRE HYDRANT INSPECTION REPORT

XYZ WATER WORKS

HYD. NO.	LOCATION	MAKE	CLASS	PRESSURES				FLOW	MINUTES FLUSHED	WATER USED	PAINTED	DRAIN	BRANCH VALVE	REMARKS OR REPAIRS
				NOZZLE	INITIAL	RESID.	PITOT	G.P.M.		GALS.				
191	CANADA & TEXAS	XXX	A	4½	80	5		1220	8	9760	Yes	O.K.	O.K.	
207	NEBRASKA & TEXAS	XXX	A	4½	86	16		2190	4	8760	"	O.K.	O.K.	
98	CALIFORNIA & TEXAS	XX	B A	4½	93	-	4	1090	9	[illegible]	"	O.K.	O.K.	[illegible]
942	CALIFORNIA & TEXAS	XXX	B	4½	77	-	3	[illegible]	15	[illegible]	"	[illegible]	O.K.	
711	CANADA E. OF TEXAS	X	B	4½	88	3		[illegible]	22	[illegible]	"	O.K.	O.K.	
119	MICHIGAN W. OF FLORIDA	XX	A	2½	84	31		930	40	37200	"	O.K.	?	[illegible]
602	OHIO S. OF GEORGIA	XXX	C	2½	68	9		900	18	8000	"	O.K.	O.K.	Needs new operating nut
										[illegible] gals.				

FLUSH HYDRANTS IN ORDER LISTED. REPORT REPAIRS ON HYDRANT MAINT. TICKET
PAINT TOPS & NOZZLE CAPS: CLASS A - GREEN; CLASS B - ORANGE; CLASS C - RED.

DATE 9-29-49 BY Richard Roe

Fig. 15. Routine Hydrant Inspection Report

NOTE: The first four columns are filled out in advance by the Engineering Dept. Columns headed "Flow" and "Water Used" are filled out by Engineering Dept. after reports are turned in. All repairs should be reported on form Fig. 14.

between symbols because of similarity in appearance. Symbols should be simple in design and easily drafted with ordinary instruments.

The suggested symbols here presented were selected because of their simplicity, clarity and acceptance in present practice. This list of symbols is necessarily incomplete and is presented to cover only the most common of the items found in a water distribution system.

The employment of these symbols should be handled judiciously. Various symbols are presented to represent the same structural item,

(5" X 8" SHEET)

SERVICE MAINTENANCE REPORT

XYZ WATER WORKS ____________ TAP NO. 35631

ADDRESS 7273 Nebraska Ave.

ACCT. NO. 14/858 DATE TROUBLE REPORTED 9-30-39

NATURE OF TBOUBLE Leak at curb cock.

COMPLAINT MADE BY Mrs. S. Sidney

CLEANED SERVICE —

THAWED SERVICE —

REPAIRED LEAK IN INLET SIDE OF CURB COCK

REPLACED CORP. —

REPLACED STOP COCK —

REPLACED OR RESET STOP BOX LOWERED BOX 6".

REPLACED SERVICE ____________

ANY OTHER WORK NO

SLIGHT LEAK IN WIPED JOINT —

WORK PERFORMED 10-2-39 BY Jim Jones

FIG. 16. Service Maintenance Report

REPORT OF LEAK

XYZ WATER WORKS NO. 231-1939

LOCATION California - East of Texas

TIME REPORTED 9:10 P.M. (HOUR) Fri. (DAY) Sept. (MONTH) 29 (DAY) 1939 (YEAR) BY (TELEPHONE ✓ (CALL AT OFFICE (LETTER

REPORTED BY C. Jamison ADDRESS 7290 A California

REPORT RECEIVED BY Addison Sims

DISPOSITION OF REPORT Called Geo. Brown to gather crew and go to leak

— OFFICE RECORD —

REPAIR CREW REPORT RECEIVED AND FOUND SATISFACTORY Yes

INJURY OR DAMAGE INSPECTED BY A. Scott DATE 9-30-39

ESTIMATE OF EXTENT OF DAMAGE \$75.00

IS SUPPLEMENTARY REPORT NECESSARY? Yes SUPP. REPORT ATTACHED Yes

SHOULD REPORT OF THIS LEAK GO TO LEGAL DEPT.? Yes

HAS REPORT BEEN MADE TO LEGAL DEPT.? Yes

— REMARKS —

(REPORT OF REPAIR CREW ON REVERSE SIDE)

FIG. 17. Leak Report

REPORT OF LEAK BY REPAIR CREW

EXACT LOCATION OF LEAK California Ave.
40' East of Texas Ave.

SIZE AND MATERIAL OF PIPE 6" C.I.

DESCRIPTION OF RUPTURE OR BREAK Transverse Crack

PROBABLE CAUSE OF RUPTURE OR BREAK Pipe resting on large boulder

QUANTITY OF WATER ESCAPING (ESTIMATED G.P.M.) 300 G.P.M.

EXACT TIME CREW REACHED SITE OF LEAK 10:05 P.M. Fri. Sept. 29, 1939

" " FLOW OF WATER WAS STOPPED 10:20 " " " " "

" " WATER ON AFTER REPAIRS 2:30 A.M. Sat. Sept. 30, 1939

WHERE DID WATER ESCAPE TO Went to sewer, except about 50 G.P.M. which ran into basement of store – 7290 California.

DESCRIBE DAMAGE CAUSED BY ESCAPING WATER Wet about 24 Boxes of Shoes

DESCRIBE ACTION OF EMPLOYEES TO MINIMIZE DAMAGE Moved boxes off wet floor

NAMES OF EMPLOYEES AT LEAK:	NAMES AND ADDRESSES OF OTHER WITNESSES:	
A. White	C. Jamison	7290 ½ California
C. Gray	R. Swan	7306 Nebraska
F. Black	C. Jacobs	7220 Michigan

REMARKS Small Gasoline Pump # 2 did not operate satisfactorily. Trouble in gas feed.

(USE OTHER SIDE FOR ADDITIONAL REMARKS)

REPORT BY Geo. Brown

FIG. 17. Leak Report, Reverse Side

depending upon the scale of the record and the use to which the record is put. In some cases an item symbol is shown for use on a large scale record while none is given for use on a small scale map, because of the undesirability of picturing items of minor importance on summary maps.

The use of too many symbols is undesirable. Often a clearer representation of an item may be obtained by the use of abbreviations or initials properly positioned on a map. Examples are: blowoff, B.O.; electrolysis bond, El.B.; air relief valve, A.R.V.; pressure relief valve, P.R.V.; bypass, B.P.

Each water utility should, as a part of its record system, provide each employee concerned with making job sketches, keeping distribution system records or using such records, a print showing the symbols in use and the features they represent. Prints of the adopted standard symbols should be placed in all copies of each record book.

Figure 18 shows suggested symbols for use on the various types of mapped records.

In a following section on "drafting suggestions" are given suggestions in regard to the uses and construction of certain of these symbols.

Records for Small Systems

Water works systems for small cities and towns require the same sound management and accounting as do water works systems for large cities. However, due to less complex distribution systems, closer contact of the personnel with the water works system, and more direct operation and accounting procedures in smaller cities, it is possible to obtain the same efficiency in record keeping in a more simple manner. This may be achieved largely by combining certain of the records described heretofore without the loss of necessary and valuable information.

Mapped Records. The primary mapped record for a small system supplying less than 5,000 population should be a detailed map record very similar to the sectional plat record (see Fig. 2). This record should be made at a 100-foot scale and, if possible, on a single sheet of tracing cloth. If the system is more than 4,000 feet wide, two or three sheets of 42 inch wide cloth may be necessary. All of the information shown on the sectional plat record as described in a preceding section, should be included on this record. In addition,

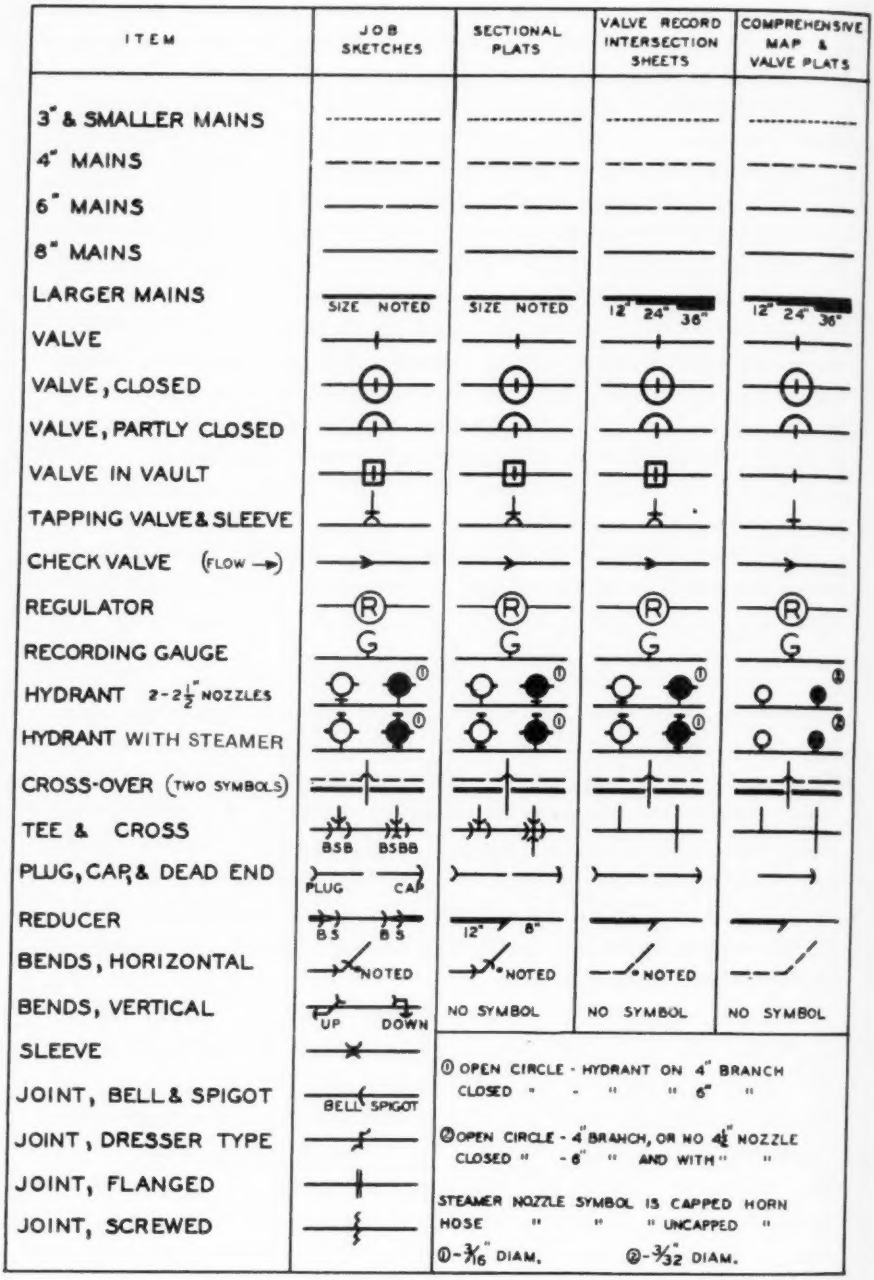


Fig. 18. Symbols

reference measurements to all valves should be shown, the reference points being property or curb lines. Prints of this record will furnish all of the operating information necessary for a small system.

The 100-foot scale will allow ample room for inserting all the necessary information without requiring ultra-fine drafting work. This record should not be kept on linen but on tracing cloth. If an original linen record is allowed to receive everyday use, it will require replacing in a few years, and the job of re-drawing this linen record will be such a burden that it will probably never be done. The prints of this record should be brought up to date with red ink every time an addition or correction is required. As of the end of each year the changes should be transferred to the cloth tracing and new prints made. All prints should be black line on white background.

For very small towns, or where it is felt desirable to show other structures, such as sewers, on the detail map, the scale should be 50 feet per inch.

Valve Records. For the smaller towns, measurements to all valves are shown on the detailed map mentioned above. It is recommended that all valves and their reference measurements be also shown on a valve list record, which need not be accompanied by valve plats.

For cities of two to ten thousand population, the valve record should be of the "plat and list" type, unless an intersection sheet record is in use. As stated in the section on valve records, the valve plat may well be the comprehensive map drawn to a scale of 300 or 400 feet per inch on which the valve numbers are shown. A book containing the valve lists and sketches of any complicated intersections will complete the record.

Card Records. The valve, fire hydrant and consumer's service card records have the same high degree of importance in a small water works system as in a large system. These records should be faithfully kept.

Statistical Records. The records outlined in the section on this subject should be followed by utilities of any size.

Work Orders and Reports. The forms shown in this section should be suitable for a small system as they are much simpler than the forms often necessary in large city systems.

Maintenance Records. Forms similar to the maintenance forms, Figs. 11 to 17, should be provided. All maintenance work performed should be transcribed to the proper card records.

Drafting Suggestions

The preparation of the maps and plats necessary to show properly the numerous distribution system records can often be facilitated by using various tools and devices. There are also a few general rules which should be followed. This short section will try to describe a few of these rules and devices.

Inked Lines. Since the original tracing cloth records are intended for many years' use, it is essential that the inked lines be heavy enough to withstand ordinary wear. If very thin to start with, the lines will, in a few years, become too faint to show properly on prints.

Heavy lines, depicting large mains, can be made by repeating thin lines until the proper width is obtained. The ruling pen should not contain a large quantity of ink.

Cross-Overs. Where it is necessary to indicate a cross-over of 4-, 6- or 8-inch pipe depicted with either broken-line symbols or lines of basic width, the loop method should always be used. Where a cross-over involving a large main occurs, the heavy line depicting the larger main should be broken.

Parallel Mains. Parallel mains in the same street should be kept far enough apart in the construction of the various maps so that gate valves on one will not touch the other, and so that there will be room to insert all present or future bypass connections between them. Occasionally it may be best to neck down the line representing a large main so that additional room may be obtained to show valved bypasses between parallel mains, rather than spread the mains too far. Examples of this practice are shown in Fig. 1.

Broken-Line Symbols. Especial effort must be made to draw the broken-line main symbols (4- and 6-inch) so they will make actual contact at each intersection, present or future. Where one of these small mains crosses an intersection, a solid portion of the line should be made to cover the intersection. Care must be taken to make the necessary break in each block of 6-inch pipe, no matter how short.

Dead-End and Reducer Symbols. Discretion should be observed in the use of these symbols. They should be omitted in all cases where the change in pipe size or the existence of the dead end is self-evident.

Positioning Street Names. As a general rule it is desirable to place street names on the side of the main further from the near property line. It is also desirable to plan for the future and not letter names across streets at present without mains; if necessary, the name can

be broken. The use of abbreviations "St." and "Ave." following the street name, but spread a considerable distance from the name, allows positive identification of long streets without such frequent repetition of names that the map becomes predominantly a mass of lettering. For short streets these abbreviations should be omitted unless the suffix is necessary to differentiate between another street of the same name but having a different suffix.

Reproducing Tracings. When tracings become worn and soiled, it is often cheaper to have reproductions made by the photo-lithography process than it is to redraw them. When obtaining such reproductions it is advisable to specify that the ink must adhere to the cloth permanently, and will not crack off.

Also where it is desirable to keep other records, such as of sewers, etc., on the master sectional plats prepared for showing distribution system records, the plats can be prepared showing street, property and lot lines. Before adding the lines depicting the water works structures, these tracings can be reproduced at reasonable cost for use by other departments.

Pantograph. The ordinary wooden pantograph, which can be purchased for three to six dollars, is a great help in reducing or enlarging subdivision plats, etc., for insertion into the existing maps. It will usually be necessary to bore additional holes in the pantograph sections to obtain proper reduction ratios.

Shadow Box. A shadow or transparency box is a time saver where it is necessary to retrace existing drawings which are very often soiled and have little contrast. This is merely a suitably framed piece of heavy glass, which has had the underneath side sand blasted, etched with acid or rubbed with a carborundum stone to diffuse lights beneath the glass. A white reflector behind the lights is desirable. Two or three daylight white fluorescent lamps make a fine light source.

Lettering Sets. The use of lettering sets will enable an otherwise mediocre draftsman to produce excellent work. While slightly slower than free hand lettering, the higher quality of work which these sets will produce may be worth the extra time. Titles should be made wherever possible with a lettering set.

Rivet Pens. Since a great many small circles must be drawn to show the many fire hydrants in the usual water distribution system, the use of a "rivet" pen will be found preferable to the ordinary bow pen.

Scotch Tape. This recent development has many uses in the

drafting room. It can be used to "tack" work to the glass surface of a shadow box. It will also hold tracing paper or cloth on maps which thumb tacks would mar. Where it is necessary to place successive dates on tracing cloth originals after they have been corrected, these dates can be inked on transparent scotch tape placed on the tracing. The tape and the inked date can be easily removed, making it unnecessary to ruin the tracing by successive erasures.

Erasing Machine. The small electric erasing machines pay for themselves in speeding up erasures. Their use, along with an erasing shield, will allow extensive erasures to be made with small damage to the tracing cloth.

Washing Off Pencil. It is often necessary to remove pencil marks from the inked tracing cloth originals. This can be quickly done with a soft rag moistened with benzine or cleaners' gasoline. The solvent must evaporate completely without leaving a greasy residue.

Printed Tracing Cloth. Where it is necessary to make a large number of tracings which have a common form (such as the valve lists, Fig. 4), the basic information can be printed on the sheets at a cost much below that of preparing the forms by hand.

Rubber Stamps. It is often necessary to repeat many times words such as scale, sheet number, etc. on the numerous drawings. Rubber stamps, with the proper ink, will speed up such routine work.

Personnel of the Committee

William G. Banks	Harold B. Gotaas
Albert R. Davis	Bard Livingstone
John C. Detweiler	A. B. Manson
Roger W. Esty	Frederick Ohrt
Maurice N. Gerardy	George Tatnall

W. Victor Weir, *Chairman.*

Economies in Office Forms

By Israel Rafkind

MOST offices can profit by carefully examining the accounting documents and records they now use. Some offices have far too many forms; others could use the same number more economically. Practical suggestions for economies in preparing and using forms are contained below.

The courts now generally accept loose-leaf records as good evidence. As a result, the trend is away from "well-bound" books and toward wider use of loose-leaf forms. The latter, which can be kept in ring, post or other binders, are more flexible and tend to reduce waste.

The first step in effecting planned and coordinated forms should be a survey of documents and records used at present. The fundamental question to determine is whether each separate form and all copies are necessary. The following questions may aid in this determination: (1) What is the purpose of each form? (2) What purpose does each copy serve? (3) How is each copy finally filed or otherwise disposed of? (4) How many copies of each form are used annually?

Often space is provided for more information than is necessary. Eliminating unused portions may save on both paper and printing costs. At times two or more forms may be combined into one. To test whether similar forms can be combined, simply list all the data appearing on the more detailed form. Check all the data on this list which also appears on the other form, and then separately list the information found only on the latter form. A brief study then should indicate whether and how the forms can be combined.

Sometimes combinations are possible with a few changes in the basic document. For example, many places eliminate a separately printed Receiving Report by using an extra carbon copy of the

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Purchase Order. Where one-time carbon is used, this can easily be done by blanking out on the last carbon sheet the space covering the quantity, price and amount columns. Not only does this save on printing costs, but clerical effort also is reduced since required information such as order number, vendor's name, etc., already is on the receiving report copy of the form.

Economies can also be effected by giving wider scope to the adoption of forms carried in stock by stationers instead of using specially printed forms. Smaller municipalities particularly should consider the adaptability of standard forms. In many instances plain columnar sheets can be adapted to particular needs by filling in the desired columnar headings. Common uses for standard stock forms are: General Journal; General Ledger; Cash Receipts Record; Cash Disbursement Record; Expenditure Analysis Record; Payroll Distribution Record; Inventory and Stock Records; Bond and Interest Records.

Stock forms may be punched for various binders. If it is desired to order new forms which fit binders already on hand, the correct punching should be indicated. The usual hole punches for post binders are $\frac{3}{8}$ in. or $\frac{5}{16}$ in. The distance between hole centers normally is $6\frac{3}{8}$, $7\frac{1}{8}$, $8\frac{1}{4}$ or $10\frac{1}{2}$ in.

The first step in preparing a new form is to list the information which is to appear on it. These data should then be rearranged according to priority of emphasis. A purchase order, for example, generally would show the order number and vendor's name and address at the top. In case of forms such as purchase orders, the possibility of spacing names and addresses for use of window envelopes should be studied. If the form is to be filed, consideration should be given to the following: (1) the information which should be visible; (2) making the filing symbol conspicuous, if kept in vertical files; and (3) that the margin is sufficient for loose-leaf binders. Generally forms should be bound at the bottom, if not punched for side binding. Thus each form can be referred to conveniently. Visible records, however, usually are bound at the top since the indexed information is shown at the bottom.

The next step concerns the size of the form. The overall size should be such that the form can be cut without waste from standard sizes of paper. Often reducing a form by a fraction of an inch will save a considerable amount in paper costs. The sizes should be checked with your printer.

The grade of paper used may substantially affect the cost. *Bond* paper is used for correspondence and forms requiring ink on one side or pencil and typewriter on both sides. *Ledger* paper is used for permanent pen written records and for pen ruled forms. *Bristol board* is used for card records. The weight of the paper to be used depends upon the number of copies desired. Thirteen pound paper is used if four or more copies are to be prepared by typewriter or machine. Sixteen pound paper is used for one to four machine prepared copies and one or two copies prepared by pencil and carbon. Twenty pound is commonly used for letterheads and twenty-four pound for most ledgers.

Whether or not the form requires much folding and the period during which it will be used should influence the grade of paper used. Cheaper grades are "sulfite" (wood pulp) and best grades are entirely "rag" content. In specifying paper for the printer, the following may be used as a guide: (1) If the form is used for less than three years, specify 100 per cent sulfite. (2) If the form is used for more than three but less than six years, specify 75 per cent sulfite and 25 per cent rag. (3) If the form is used for more than six but less than ten years, specify 50 per cent sulfite and 50 per cent rag. (4) If the form is used for over ten years, specify 100 per cent rag.

A hint on the use of color may be valuable. The director of planning of New York's largest department store reported that their experience showed the red number to be less distinct and likely to produce more errors than a black number.

The following rules, based on many years of experience by a practical printer doing this kind of work, summarize the points to be considered when preparing illustrative forms to be executed by the printer and ruler: (From William R. Thompson, *Accounting Systems*, LaSalle Extension University, Chicago, 1938, pp. 324–325.)

1. Give the exact size of finished sheet.
2. If it is to be a loose-leaf form, specify binding margin, and state whether or not the sheet is to be printed on both sides.
3. Do not write the words desired printed—print them plainly in the proper position or type words on separate sheet and indicate by number just where the words are supposed to go.
4. Specify the exact space between rulings, and, if they are to be printed, specify kind of ruling desired, bold face or light face. This can be done by marking the rulings 1 point or 2 point rulings, etc. A "point" is the printer's term for measuring rule or type face. One point measures $\frac{1}{72}$ of an inch.

5. It is also a good idea to specify what size type is wanted in box headings and main headings. This can also be designated by the point system. For instance—the main heading might require 10 point or 12 point type, while the small box heading might require 6 point or 8 point type.

6. If the form is to be used in duplicate with other forms, specify on the copy, and wherever possible give a sample of the duplicate sheet to be used with the form.

7. If the form is to be used with bookkeeping machines, it is important to specify exactly the width of rulings, so that they will register with the particular type of machine for which the sheets are to be used. Before going ahead on forms of this kind, try out a sample sheet on the machine for which it is being made.

8. If the form is going to be used in connection with loose-leaf binders, give the number of holes and kind of punching desired. If the form is to be perforated, specify exactly just where the perforations are needed.

9. On some forms, where it may be necessary to print some parts and rule other parts, it is well to specify which are to be printed and which are to be ruled.

10. For instance, in many cases money can be saved in having the down lines printed and the main lines ruled, as the down lines can be printed along with the type in the same operation. Ruled-down lines, however, are ruled on a down-line ruling machine which requires an extra operation of ruling.

11. It is also well to remember in drawing up forms for the ruler that lines which run off the sheet at both ends can be ruled much cheaper than lines which do not run off the sheet. For instance, a vertical line which stops at a box heading or a horizontal line which stops halfway across the sheet makes it necessary for an extra operation which requires much more skill, and naturally, is more expensive.

12. The ruler should know just what color inks are required for the different rulings.

13. The same specifications that are necessary for the printer with regard to size, registration of rulings, etc., are also necessary for the ruler.

14. In summing up, make sure that names and words are spelled correctly and have the copy correct in every way before it goes to the printer. It is expensive to change copy, once the printer has set it up.

Coordinating Operating System Records With Accounting Records

By Nathan B. Jacobs

AT THE 1939 Annual Convention of the American Water Works Association, W. Victor Weir delivered a paper entitled, "Developing Distribution System Records" in which he discussed the First Tentative Draft of a report entitled "Suggested Standard Practice for Distribution System Records" which had been prepared by the Committee of the Association of which Mr. Weir was Chairman. The suggested standard practice in this paper included map records, card records, statistical records, work orders, and reports and maintenance records. In addition, the report submitted a set of standard symbols to be used in distribution system records. The paper does not cover accounting records but in this connection refers to the *Manual of Water Works Accounting* prepared and published jointly by the Municipal Finance Officers Association and the American Water Works Association in 1938. Both the report of 1939 and the accounting volume of 1938 are copiously illustrated with suggested forms for record and cost keeping. It, therefore, occurred to the writer that wherever possible it would be well to coordinate these two branches of the water works—first from the standpoint of reducing clerical work, second, by producing better records, and lastly, in the hope of providing a ready means of cooperation and coordination between the work of these two departments. For example, in the Tentative Report the following paragraph appears:

"*A Permanent Record of Assets* in the form of proper mapped and statistical records is as necessary as is a permanent, honest and detailed accounting of the financial expenditures. Actually, the fact

A paper presented on September 20, 1939, at the Western Pennsylvania Section Meeting at Johnstown, Pa., by Nathan B. Jacobs, President, Morris Knowles, Inc., Pittsburgh.

that an expenditure is made and entered properly in the general books of the utility means little unless a corresponding entry can be and is made in the physical assets record. The auditor's record and the engineer's record must not only balance in themselves, but each must balance with the other."

Attention was called to the fact that the *Manual of Water Works Accounting* is the joint work of the Municipal Finance Officers Association and the American Water Works Association and has been written with the idea of covering both publicly and privately owned water works systems.

Similarly, the forms drawn up by the Committee for distribution system records had this in mind as stated in the introduction to the report:

"This suggested practice is designed to meet the requirements of both municipally and privately owned water distribution systems."

At first thought, it may appear that the distribution system records for both publicly and privately operated plants would necessarily be the same and, therefore, easily standardized, while the accounting records between the publicly owned plants and the privately owned corporate accounting would be materially different. It was felt, for example, that continuing property records which are accounting records that are most susceptible for adaptation to the distribution system records applied only to privately owned companies and are of use primarily in connection with rate determinations. However, as far as rates are concerned, at least in Pennsylvania, this subject is one which is just as likely to come up in connection with municipal rates as it is with privately owned water works.

Accounts and Rate Experience in Pennsylvania

A review of the last twenty-five years' rate experience in Pennsylvania indicates the trend to be in that direction. In 1913, the Public Service Company Law was passed effective January 1, 1914, creating a regulatory commission known as The Public Service Commission. Under this statute, the Commission had no jurisdiction over rates and service of municipally or publicly owned utilities except that the Commission was given authority over accounting of such utilities. Effective January 1, 1918, the Public Service Commission promulgated its Uniform Classification of Accounts for Water Companies which applied both to publicly and privately owned water works. Due to a defect in the title of the Act, many of

the city and borough solicitors in the Commonwealth advised the municipal water works departments that this classification of accounts did not apply to publicly owned water works. For this reason, the municipal water works that adopted this system was the exception rather than the rule.

However, the law was amended to give the Public Service Commission authority over rates and service furnished by the water departments of cities of the third class outside of the corporate limits of the city.

During this time, there were two notable cases involving the rates of municipal water works which came before the State Supreme Court. The first was that of Barnes Laundry Company vs. Pittsburgh, 266 Pa. 24, in which a number of the large consumers of water joined together to compel the City of Pittsburgh to lower its rates to large consumers, and the second was the more recent case of Shirk vs. Lancaster City, 313 Pa. 158 (1933). In both of these cases, the municipality was successful in meeting the complaint. In the City of Pittsburgh case, the Court held that the City was fully within its power in fixing the rates, while in the Lancaster case the Court went a step further and stated:

"In general, however, the business of supplying water by a municipality must be regarded and dealt with in the same manner as that of a private corporation."

In conclusion, the Court takes the basis for rate making for municipalities almost identical with that which the Public Service Commission had adopted for privately operated corporations when it stated:

"We summarize from the record as follows:

"(a) The present fair value of the entire plant should be ascertained and that part used or useful in service outside the city deducted.

"(b) A sum should be ascertained to cover operating expenses and contingencies; there should be deducted from it that portion necessary for service outside the city.

"(c) A depreciation charge should be set up.

"(d) It must then be ascertained whether the rates as fixed after allowing for (b) and (c) yield more than the fair return permitted on the present value of the plant to incorporated water companies as fixed by the Public Service Commission and this court (see Ben Avon Borough v. Ohio Valley Water Company, supra). If it does, the amount of return allowable should be stated, and the city should

be directed to adopt a schedule of rates within that sum and items (b) and (c).

"(e) Debt service charges, as discussed, may be compensated from such return.

"(f) Governmental expenses may be paid from the residue unless it manifestly prejudices a portion of the taxpayers."

Municipalities Need Good Records

From the above, it would appear that so far as rate making is concerned, municipalities are obligated to keep their records in as good shape as are privately owned corporations. Both publicly owned and privately owned water works are subject to the jurisdiction of the Department of Health. The State Water and Power Resources Board has equal authority over privately owned and publicly owned water works. In the matter of security issues, while the privately owned water works must obtain permission of the Pennsylvania Public Utility Commission, the municipal water works must obtain permission from the Secretary of Internal Affairs. The present Public Utility Law gives the Commission jurisdiction over any municipal utility insofar as it renders or furnishes any public service beyond its corporate limits. Practically every municipal water works has some consumers outside of the municipal boundaries and even though these consumers are few and the supplying of service to them is a mere incident to the rendering of public service within the municipal boundary of the city or borough by which the water works is operated, the sustaining of the rates against any such complaint virtually involves a consideration of the entire investment of the municipal water works. Recently, a complaint was made to the Pennsylvania Public Utility Commission by the supervisors of Harmony Township, Beaver County, against the rates charged by the Borough of Ambridge for water service in that township. Here the Commission found:

"Under all of the facts and circumstances in the instant proceeding, it appears to us that marked differences in conditions in the areas within and without the Borough are not present, so that the normal rule of ratemaking would apply, based upon the unit of the water system as a whole and that the rule in Shirk v. Lancaster City, supra, is not controlling. The principal question to be decided here is whether circumstances justify segregation. The Commission resolves this question against respondent and holds that segregation is not justified."

It will be noted from the above that the rates are fixed on a system wide base. This decision, which shows the point of view of the State regulating body, has been reversed by the Superior Court, which has permitted a municipality furnishing water service to charge higher rates outside of its municipal boundries and stated:

"It follows from these principles that a municipality may discriminate between its consumers within its limits and those without; that while it is entitled to charge rates that will return a fair profit based on the present fair value of all its property used and useful in the public service, it may forego such profit as respects its consumers within its limits and demand it of its consumers outside its limits; that in arriving at the fair value of its property for the purpose of fixing just and reasonable rates to its consumers within the city, the value of the property outside the city or borough must be segregated and deducted from the value of the entire plant, and the value of the property within the city thus be ascertained in fixing the fair and reasonable rates to be charged for water within city limits; and that the rates to be charged consumers outside the city must cover a fair return on the property thus devoted to the public service outside city limits plus a fair proportion of the value, cost and expense of the plant within the city; and that no part of the burden of furnishing water to consumers outside the city can properly be placed on its citizens and consumers within city limits.

"This, in effect, requires a segregation and allocation as between consumers inside and outside the city in order that the courts may determine the fair and reasonable rates which may be charged by the city for water within its limits and a like segregation and allocation in order that the commission may determine the fair and reasonable rates which may be charged by the city for water furnished without its limits."

Following the lead of the Public Service Commissions in other states, notably Wisconsin and New York, the Federal Power Commission has adopted uniform classifications of accounts for both gas and electric companies which require the establishment of a continuing property record. Early in 1938, the Pennsylvania Public Utility Commission issued its General Orders Nos. 47 and 48 prescribing continuing property records for gas and electric utilities as provided in Section 502 of the Public Utility Act which defines continuing property records as follows:

"The commission may require any public utility to establish, provide, and maintain as a part of its system of accounts, continuing

property records, including a list or inventory of all the units of tangible property used or useful in the public service, showing the current location of such property units by definite reference to the specific land parcels upon which such units are located or stored; and the commission may require any public utility to keep accounts and records in such manner as to show, currently, the original cost of such property when first devoted to the public service, and the reserve accumulated to provide for the depreciation thereof."

No such order has been made on the water utilities to establish such a record. However, in view of the fact that the National Association of Railroad and Utilities Commissioners have incorporated, in their recently issued uniform system of accounts for water utilities, requirements under utility plant account instructions which virtually necessitate the establishment of units of property and a continuing property record, it may not be amiss to assume that some such system will be promulgated in the Commonwealth of Pennsylvania. The uniform system of accounts prescribed for water works corporations by the Public Service Commission of New York, effective May 1, 1938, includes the same instructions as those referred to in the system of the National Association of Railroad and Utilities Commissioners. Recently, there was issued a "List of Retirement Units for Water Utility Property" prepared by the Committee on Statistics and Accounts of Public Utility Companies of the N. A. R. U. C., showing that this subject is in the offing.

Record Cards Adapted as Accounting Forms

In the tentative draft of the report on distribution system records' there are incorporated a number of forms upon which the records are to be kept. The writer has attempted to take several of these record cards from the report and show how they could be adapted as accounting record forms, particularly for a water works system which is using the continuing property record. In doing this, the writer must acknowledge his appreciation of the able suggestions and assistance which he received from the Pittsburgh representative of the McBee Company and, particularly, to Brooks Ely who assisted in preparing the original cards accompanying this paper. In drawing up these cards, the form of the McBee Company was used purely for illustrative purposes. Cards, which are of use for statistical purposes, are also made by the International Business Machine

Company and could probably be adopted in the same manner as illustrated here with these particular cards.

The reason for suggesting the use of the punch card system is because of the adaptability of these cards for use in compiling statistical as well as financial data. It is generally necessary in connection with annual reports to determine, for example, the number of meters of each size and generally also their division by municipal subdivisions. Statistical summaries are generally prepared each year showing the number, size, type, and location of mains, valves, service lines and hydrants. With the punch card system, the preparation of such summaries is greatly simplified and the restoration of the cards to their original order and location is expedited. For this reason, the cards used as illustrations here are of this type.

It is proposed that when the work order is completed and the report made out on it by the construction or maintenance department, that the record be furnished to the accounting department and this department will be responsible for making out the record cards to be kept both in the accounting department and also in the operating or distribution system department. It is felt that the facilities for making cards, particularly typewriting them, are better in the accounting department and since the work order naturally comes back to that department, it seems the logical depository for the original records. Then a clean, neat record is returned to the operating department. By using a double card with a good quality of non-smudge carbon paper, it is possible to make out two cards at the same time embodying all of the essential records of both departments. The type of cards which the writer has designed makes it possible in each case to incorporate all of the records which are essential to both departments in the upper part of the card leaving the bottom portion of the card available for cost records in the accounting department and for maintenance or service records in the operating department.

The distribution mains card was designed to keep an accurate record not only of the pipe but of the other important factors involved in the cost of laying a pipe line. It has been the writer's experience that many important data in regard to the cost of pipe laying have been lost due to the incompleteness of the records maintained by most water utilities. Figure 1 is an attempt to correct this condition. Upon this card are data giving the municipality and street location of the main, the year laid, size and material. With the

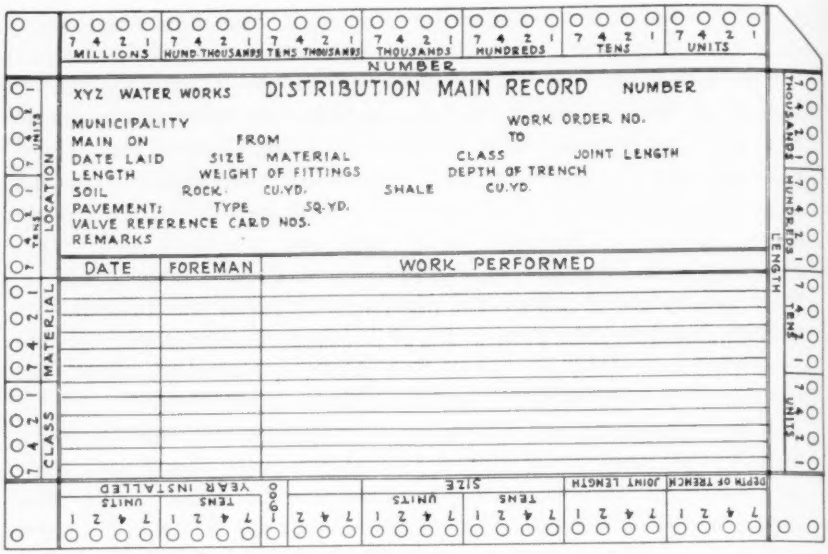


FIGURE 1

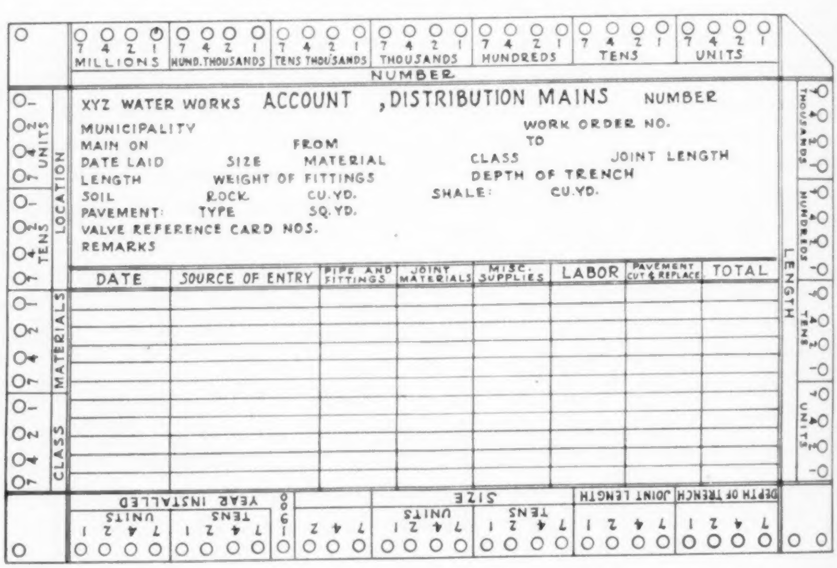


FIGURE 2

introduction of asbestos cement pipe and centrifugal cast-iron pipe of various lengths, it becomes necessary to indicate the material, class and joint length of the pipe. The length indicates the overall length of the extension with a separate card for (1) each size or kind, (2) each street and (3) each municipality. The weight of the fittings will be obtained from the fittings actually used by the construction crew. Data required for excavation costs include the soil type, amount of rock, amount of shale, type and quantity of pavement cut. Each valve installed on the extension is listed on a valve card similar to Figs. 7 and 8. The remarks would indicate the amount of machine excavation, lineal feet of wet trench and any other data which would be of interest in developing costs for valuation purposes and particularly for retirements. The lower half of the card filed with the operating department (Fig. 1) keeps a record of all maintenance while the accounting record (Fig. 2) shows the itemized cost of the extension, which can be reduced on a per foot basis for retirements.

The consumer's service card prepared for the committee's report gives all the essential data as to the location of the service line, its size, material, and fittings. Then there is provided at the lower part of the card a record of the maintenance on the service line showing the date, the name of the foreman, and the work performed for each job. Figure 3 shows this card readapted to include not only the records shown on the card in the committee's report, but also a sketch printed on the card so that it can be filled out from the work order locating the service box both in distance from the curb line, assuming there is a curb line, and tied into both corners of the house. Incidentally, the main is located from the service box so as to give the length of the service line. This diagram could have been put on the back of the card but the writer believes that there is enough space on the front of the card for jobs on any one particular service line. The particular example which has been used here has been put on a punch card system so that it would be available for statistical purposes, although this would not be essential since the next card (Fig. 4), which is the accounting record, would be on a punch card so that the statistical data would be available to the department of accounts and if required by the operating department could be furnished to them by the accounting department. If cards (Figs. 3 and 4) are compared, it will be noted that the upper part of the card is identical; that if these two cards are printed together so that they will fold one

on top of the other, the top part of the card can be filled out on the typewriter for the operating department with a carbon onto that part of the card which is to remain in the accounting department for its records. Then the lower part of Fig. 3 will give the accounting data showing the cost divided between pipe and fittings, curb cock, curb box, pavement cut and replaced, etc. Since the account number and the location are both put on at the same time, there will be no question, in case of any additional work having been done on this particular service line, that the entry will be made in the accounting department on the same unit about which the operating department has intended when it did the work and notified the accounting department through the work order.

In the same manner, cards have been drawn up for the hydrant records in the report of the committee. Figure 5 shows the same data placed on a punch card so that it can be used for statistical purposes. However, as stated before, this is not essential because Fig. 6 shows the accounting record card which will be a carbon copy of the hydrant record card and all statistical data can be obtained from the accounting department. However, since the cost of the cards is a very small item compared with the cost of making out and keeping the cards up to date, it may be desirable to keep both records on the punch card system.

There is no record in the operating department that is more often needed on short notice than that of the valve record. As a usual thing, the operating department has an accurate or better record of its valves, their type, as to whether they are right-hand or left-hand turn, and as to the number of turns than any other item in the system. On the other hand, there is probably less information available as to cost of particular valves in the system so that the retirement of the valve or the ascertaining of its cost is practically an impossible job because the cost of the valves and particularly the labor in installing them are incorporated with the cost of the mains themselves. The same valve record data as prepared by the committee and included in its tentative report are included in Fig. 7 on a punch card system. No provision is made here for a sketch or diagram of location as was done on the service line card because the locations of the valves will not, in general, be so uniform as to be indicated diagrammatically as was done with the service boxes. Therefore, as suggested by the committee, the sketch is placed on the back if necessary. Probably the sketch in most cases will not be necessary

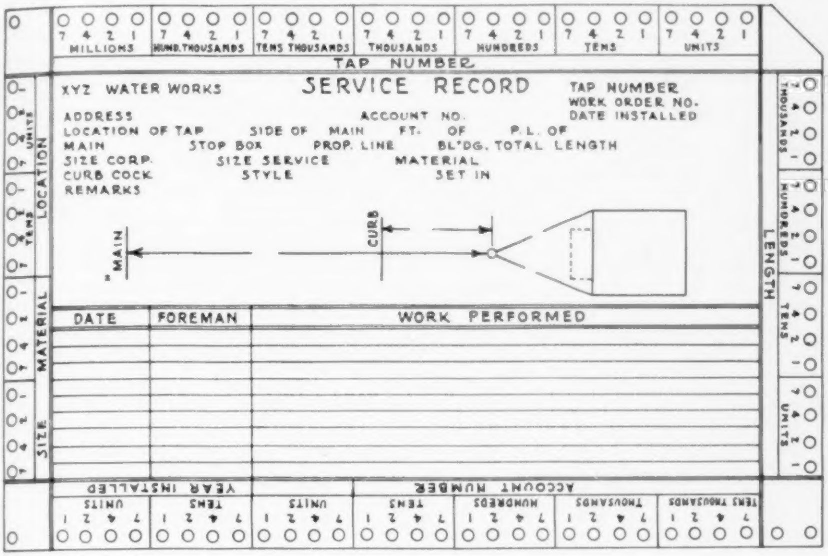


FIGURE 3

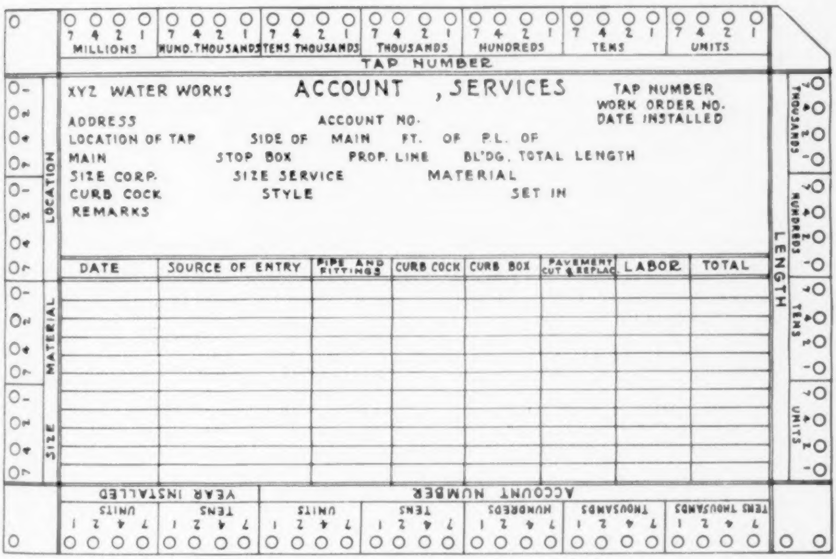
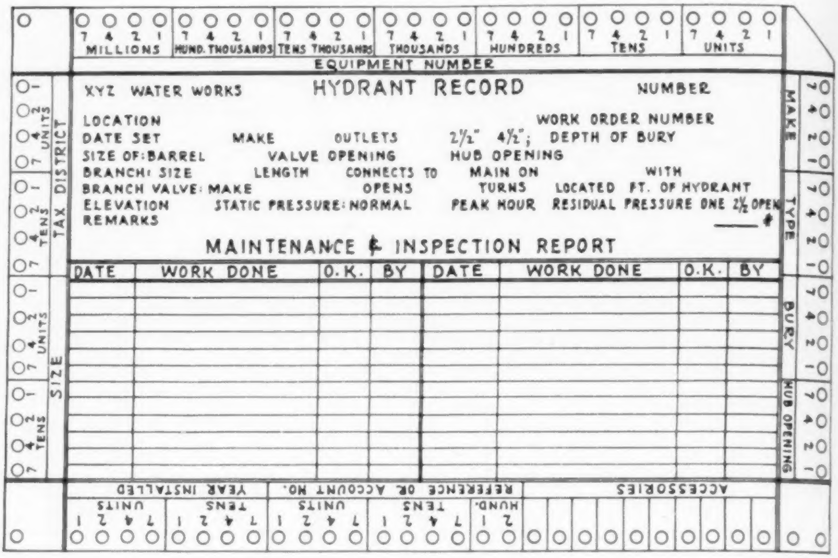


FIGURE 4


7 4 2 1 MILLIONS | 7 4 2 1 HUND. THOUSANDS | 7 4 2 1 TENS THOUSANDS | 7 4 2 1 THOUSANDS | 7 4 2 1 HUNDREDS | 7 4 2 1 TENS | 7 4 2 1 UNITS
EQUIPMENT NUMBER

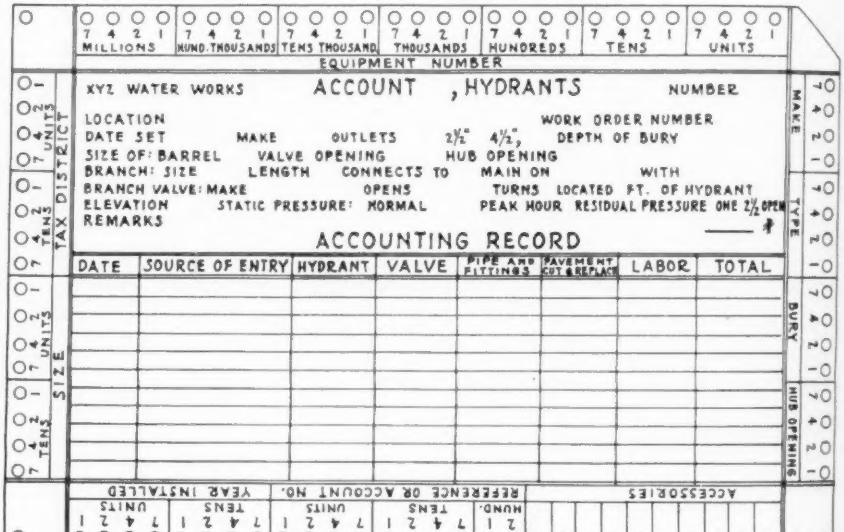
XYZ WATER WORKS HYDRANT RECORD NUMBER
LOCATION WORK ORDER NUMBER
DATE SET MAKE OUTLETS 2½" 4½"; DEPTH OF BURY
SIZE OF: BARREL VALVE OPENING HUB OPENING
BRANCH: SIZE LENGTH CONNECTS TO MAIN ON WITH
BRANCH VALVE: MAKE OPENS TURNS LOCATED FT. OF HYDRANT
ELEVATION STATIC PRESSURE: NORMAL PEAK HOUR RESIDUAL PRESSURE ONE 2½ OPEN
REMARKS ——— #

MAINTENANCE & INSPECTION REPORT

DATE	WORK DONE	O.K.	BY	DATE	WORK DONE	O.K.	BY

TAX DISTRICT: UNITS 1 2 4 7; TENS 1 2 4 7
SIZE: UNITS 1 2 4 7; TENS 1 2 4 7
MAKE 1 2 4 7 | TYPE 1 2 4 7 | BURY 1 2 4 7 | HUB OPENING 1 2 4 7
YEAR INSTALLED: TENS 1 2 4 7; UNITS 1 2 4 7 | REFERENCE OR ACCOUNT NO.: HUND. 1 2; TENS 1 2 4 7; UNITS 1 2 4 7 | ACCESSORIES

FIGURE 5


7 4 2 1 MILLIONS | 7 4 2 1 HUND. THOUSANDS | 7 4 2 1 TENS THOUSAND | 7 4 2 1 THOUSANDS | 7 4 2 1 HUNDREDS | 7 4 2 1 TENS | 7 4 2 1 UNITS
EQUIPMENT NUMBER

XYZ WATER WORKS ACCOUNT, HYDRANTS NUMBER
LOCATION WORK ORDER NUMBER
DATE SET MAKE OUTLETS 2½" 4½", DEPTH OF BURY
SIZE OF: BARREL VALVE OPENING HUB OPENING
BRANCH: SIZE LENGTH CONNECTS TO MAIN ON WITH
BRANCH VALVE: MAKE OPENS TURNS LOCATED FT. OF HYDRANT
ELEVATION STATIC PRESSURE: NORMAL PEAK HOUR RESIDUAL PRESSURE ONE 2½ OPEN
REMARKS ——— #

ACCOUNTING RECORD

DATE	SOURCE OF ENTRY	HYDRANT	VALVE	PIPE AND FITTINGS	PAVEMENT CUT & REPLACE	LABOR	TOTAL

TAX DISTRICT: UNITS 1 2 4 7; TENS 1 2 4 7
SIZE: UNITS 1 2 4 7; TENS 1 2 4 7
MAKE 1 2 4 7 | TYPE 1 2 4 7 | BURY 1 2 4 7 | HUB OPENING 1 2 4 7
YEAR INSTALLED: TENS 1 2 4 7; UNITS 1 2 4 7 | REFERENCE OR ACCOUNT NO.: HUND. 1 2; TENS 1 2 4 7; UNITS 1 2 4 7 | ACCESSORIES

FIGURE 6

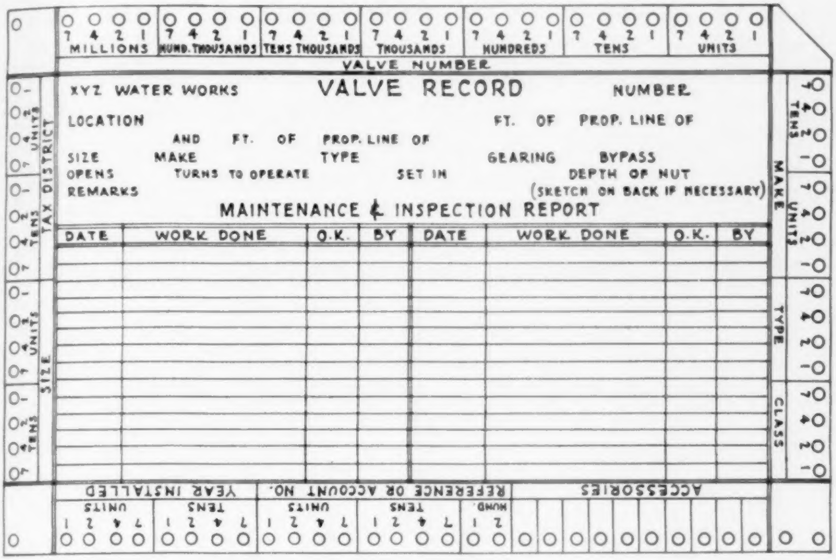


FIGURE 7

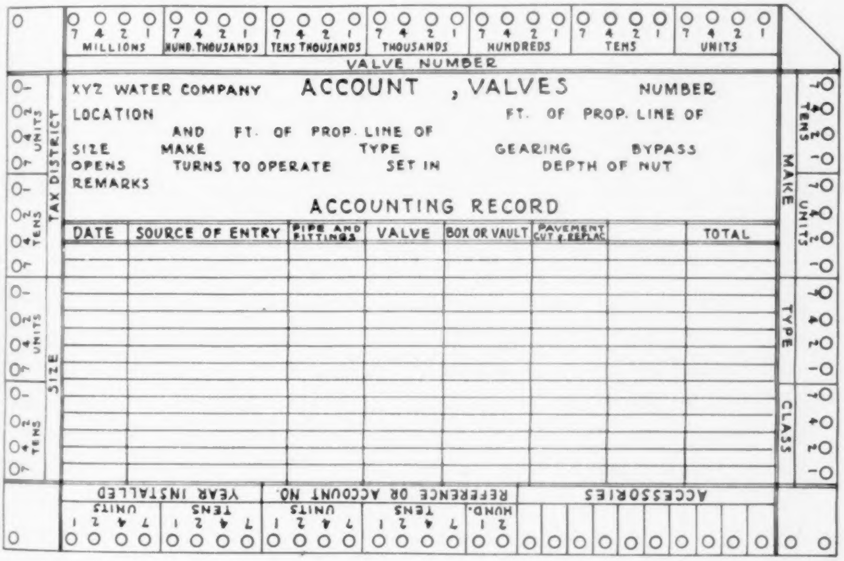


FIGURE 8

except in the case of valves on dirt or macadam streets where they are likely to be covered over and therefore not so easily detected when they are needed in an emergency. Although valves are not usually set up as a separate account in the accounting classifications but are incorporated with distribution mains, it would probably be found desirable where units of property are required under continuing property records to have a subdivision of the account, at least for the valve, and make the valve itself, together with the valve box, a separate unit of property. The card, therefore, which will accom-

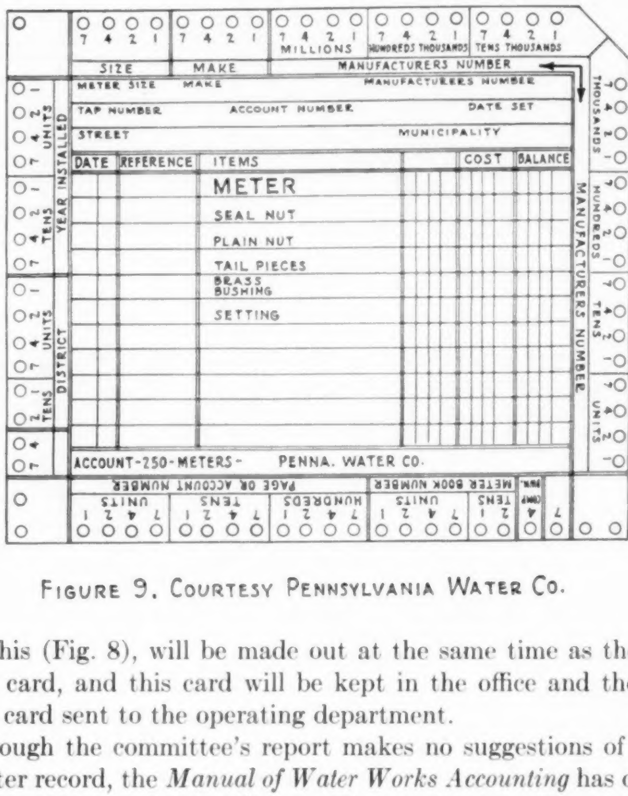


FIGURE 9. COURTESY PENNSYLVANIA WATER CO.

plish this (Fig. 8), will be made out at the same time as the valve record card, and this card will be kept in the office and the valve record card sent to the operating department.

Although the committee's report makes no suggestions of a card for meter record, the *Manual of Water Works Accounting* has on page 348 a record card entitled "Meter History Card." Figure 9 shows the meter card originally adopted by the Pennsylvania Water Company and used for accounting and statistical purposes in which the cost is derived in each case by including in addition to the cost of the meter the fittings which are used in setting the meter together

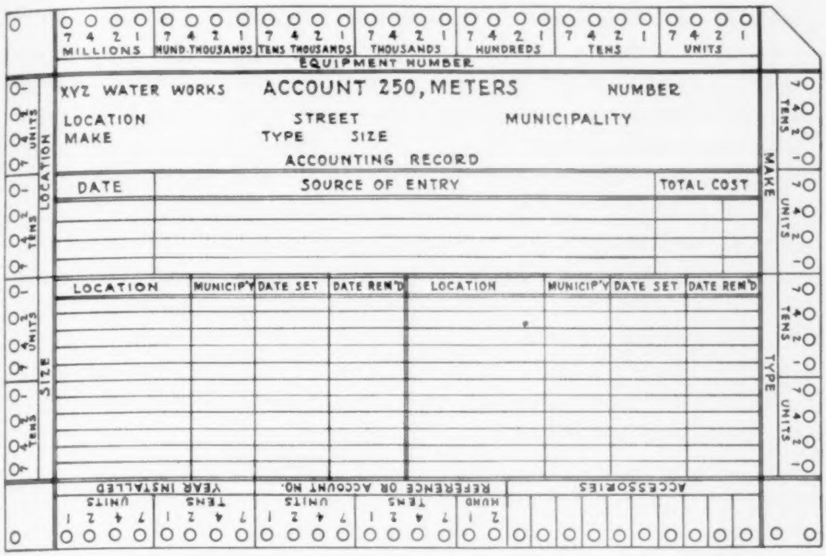


FIGURE 10

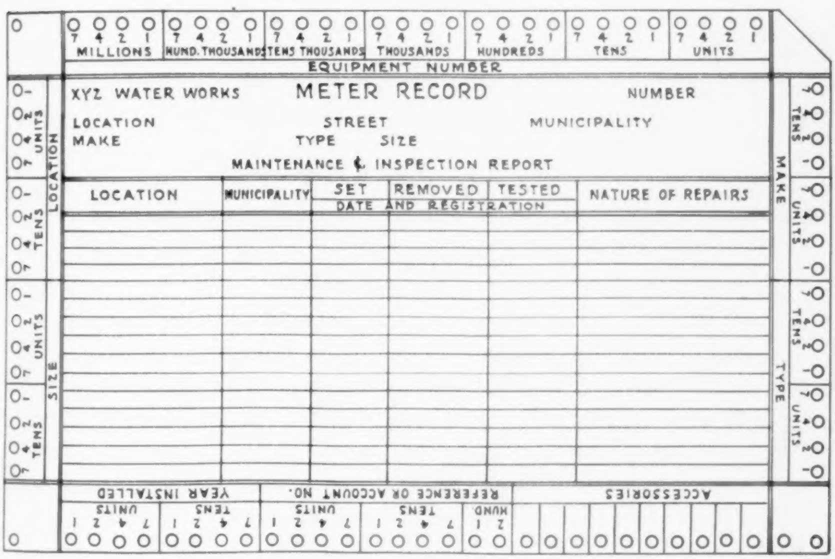


FIGURE 11

with the cost of setting. This card was designed to meet the conditions of water companies, such as the Pennsylvania Water Company, where a meter is assigned to a given location and when the house is vacant temporarily the meter is not reassigned to any other location but re-installed in the old location when a new consumer is obtained at that place. However, if the company should adopt a policy of removing meters from one location to another from time to time in the case of vacancies or when removed for testing or repairs, the meter account is generally divided in continuing property records

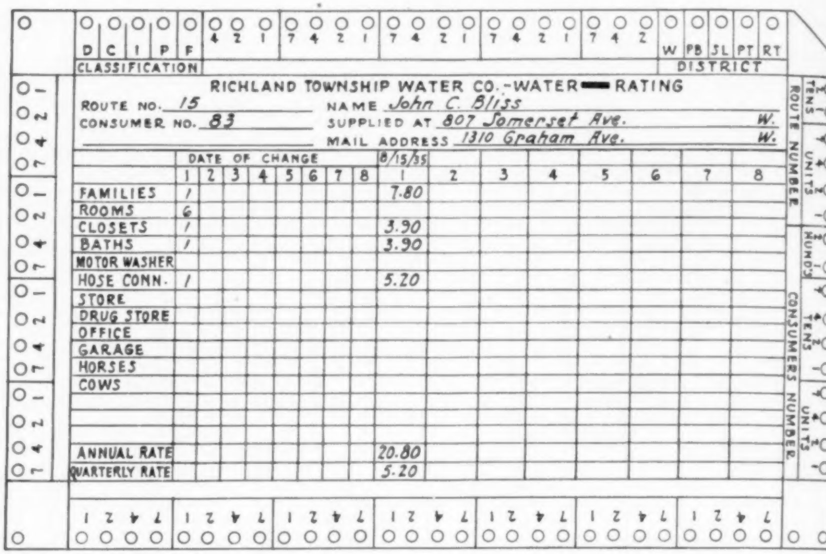


FIGURE 12, COURTESY RICHLAND TOWNSHIP WATER CO.

between meters and meter installation costs. Here a meter installation cost card would probably be similar to the card which we have used to illustrate service lines except that the meter itself would not be included. Figure 10 is the form for the record of each meter where provision is made for relocating the meter at various points in the system. The set-up is made for each municipality. Here no provision is made for cost of setting or fittings used but only the entry for the meter itself, and possibly its first original testing cost. When this meter accounting record is prepared, the carbon copy of it as shown in Fig. 11 will be the meter record for the operating depart-

ment, providing both dates and registration blanks for the resetting, removal and testing of meters and remarks for the repairs.

While it is not generally connected with the subject of this paper, Fig. 12 herewith illustrates the card designed by E. R. Hannum for the Richland Township Water Company of Windber, Pennsylvania. These cards are prepared for each flat rate consumer showing the number and type of each fixture installed and are of particular value in case of any question involving rates, whether the company is considering adjustments on its own accounts or in case there is inquiry about rates either by consumers or by the Commission. In this way the data in regard to the number of each type of fixture in the system can be readily determined by the punching on the card.

It is possible that the writer has laid too much stress on the question of rates and rate litigations, but he cannot be unmindful of the experiences which utilities had during and after the First World War from 1914 to 1918. Nothing probably was more sacred than the five-cent carfare. Nothing is more unusual now than to find it. During the year 1919 to 1922 or 1923, most of the utilities found it necessary to increase their water rates. Whether the same conditions will follow the present difficulties now taking place across the waters only time can tell.

Water Department Records and Legal Operation

By W. G. Irving

THE subject, when first assigned to the author as a part of a symposium, seemed one of doubtful definition. The author has assumed that it means recording data in such form as may be readily available and easily proven in actions instituted to establish water rights or resist their invasion. From that point of view the subject is of importance. Legal proceedings put in motion for the determination of water rights may be and usually are unduly prolonged under present methods of court procedure and, as a consequence, are costly.

The chief cause of this situation is the condition of departmental records. Data which in the ordinary affairs of life are accepted and relied upon are, when produced in court, subjected to microscopical scrutiny, and the slightest error in addition, subtraction or multiplication, even to a hundredth of a foot, is seized upon as an indication of the unreliability of the observer or computer. So common is this the case that the method pursued in the trial of water cases has become little less than scandalous. Dreary hours of cross-examination of minor officials stretch into weeks and months until the superintendents or engineers of water works systems become provoked. They see comfortable balances over expenditures disappearing in the form of court costs, lawyers' fees and compensation of experts, the result of which does not increase the supply of water or return additional profits. They are justified in their chagrin. Yet they are chiefly responsible for the condition that they deplore.

The author assumes that when an engineer undertakes to develop a water works system, he investigates the product of the source, the cost of a distributing system, computes the capital outlay required, the interest thereon, the cost of operation, maintenance and re-

A paper presented as part of a symposium on the value of water department records, on October 27, 1939, at the California Section Meeting at San Francisco, by W. G. Irving, Attorney, Riverside, California.

placement, and with the grand total in mind gives the signal to go ahead. If thought is given legal complications involving the water rights of others, or injuries which may result by reason of the development, they are brushed aside as matters to be taken care of in the future, or to be dumped in the lap of the courts and lawyers. Nothing like a lawsuit should be permitted to stand in the way of progress. In the early days, when the demand for water did not exceed the supply, this nonchalance of procedure passed without any untoward results. Today, however, when almost our entire supply in certain areas of the state is in use, any additional draft thereon is sure to be resisted. Such resistance will come from those possessing vested rights of use. Or it may be that when claimed rights are exercised, the supply temporarily is sufficient to meet all demands—a shortage occurs and then the question arises: "Who shall suffer?" The determination of these matters rests upon records, and the greater the period covered by the records and the greater the accuracy of the same, usually the shorter the trial and the less the expense.

Retaining Water Rights

The price of a water right, therefore, is not reflected in the estimates of an engineer. There should be added thereto an estimate of the cost of defense, which includes competent records. The question naturally arises—what are these records? That can be most readily answered by considering the nature of the right to be protected. The measure of a water right is the amount of water reasonably necessary to serve the purpose to which it is applied. The permanence of the right depends upon its order of priority in relation to the rights of other users. The reference here is to appropriators such as all public utility corporations and municipalities are, other than pueblos. The use must be more or less continuous. Under the decisions of our courts, non-use of water for a continuous period of five years will forfeit the right. Under the Water Commission Act three years of non-use will forfeit the right. Furthermore, the right may be lost by the adverse use of the water by another for a period of five years. Such are two ways by which the right may be lost.

In order, therefore, to preserve a water right, it must be exercised. Again it must be protected against adverse use, and any wise policy will dictate taking ways and means, and will provide funds for that purpose.

The ways and means referred to are largely the keeping of records

of the amount of water diverted from the source, the loss in transmission to the place of use, and the amounts necessary to supply such uses. Provision should be made in annual water works budgets for the payment of this expense. It will repay the water works tenfold. There is only a fixed supply of water in California. The demands for a portion of the supply are increasing year by year. A struggle is being waged by the "have nots" to take from the "haves," and this will continue until there is a change in the meteoric conditions controlling the precipitation in this state. Water companies should therefore consider that an attack on their water rights is the usual thing to expect. Provision should be made to resist it.

Taking Measurements

If a company is diverting from a surface stream, then measurements at equal intervals of time of diversions should be made by competent observers, and should be as accurate as the circumstances will permit. It is unwise in measuring large flows of fifty or more second-feet to record decimals of a second foot. In measuring small flows, more refined methods may be used, but fractions of the unit used should be disregarded. The author has known days in court to be wasted correcting hundredths of a foot in the elevation of a water table, when the only purpose of the measurement was to show the seasonal rise and fall of the underground water. Like records should be made of water lost in transmission and delivered at the place of use. Absolute accuracy is not necessary and cannot in practice be obtained. These original records should be made in books dedicated to that purpose, should be numbered chronologically, and carefully preserved. Every year it would be well to prepare hydrographs or diagrams by which the results obtained could be appraised at a glance. Such records are invaluable and the better they are prepared and preserved, the greater weight they will bear in court.

The same is true as to water rights exercised in appropriating water from underground supplies. The problem is, however, more involved in such a case. Such factors as the capacity of the underground basin, the average annual supply thereto, and the total extractions therefrom, must all receive continued attention. Otherwise, you may wake up some morning and find the right to the use of half the customary amount of water gone. The making of such observations, and the recording of the same, should be as much a routine as is any other essential activity of a water department.

Assume that records have been kept; that they are as accurate as the circumstances will reasonably permit, and that they have been given full faith and credit by the water department; even so, those facts are not sufficient to prove their verity in a court where water rights are questioned. Unfortunately something more is necessary than the mere production of such records to convince a court that they truly disclose the facts. Under present rules, it is necessary to produce the man who made the measurement and to have him testify as to the accuracy of his instruments, and even as to the character of his tape. If it be a steel tape, then the temperature of the day upon which the measurement was made may be the subject of inquiry. The possibility of expansion of a steel tape by reason of the rise in temperature seems important in some courts. If a measurement of the elevation of water in a well is made, then the barometric pressure must, according to some engineering authorities, be recorded in order that it may be correlated with that of prior and succeeding days of measurement. Such refinements are foolish. It is reasonable to assume that if engineers feel justified in making large expenditures in designing and constructing distributing systems and developing water resources upon any particular record, the same should be considered by the court as correct unless substantial errors are disclosed which will affect not any particular measurement, but the result of the entire study.

But such is not the case. As stated above, the great expense of lawsuits is the proof of records upon which engineers would act without question. Probably 80 or 90 per cent of the time spent in court is wasted in endeavoring to prove details which engineers in ordinary business would accept as a matter of course. Two days and two thousand dollars were spent in proving the accuracy of a rain gage in a water suit in San Diego County. Having proven its accuracy, the rain gage was thrown into a corner of the courtroom and forgotten. Hours have been wasted in determining whether the elevation of a well was $105\frac{5}{100}$ feet or $105\frac{4}{100}$ feet. The difference was inconsequential and would not affect the result.

The difficulty confronting courts is that laws of nature, with which engineers deal and of which they are required to have knowledge, are not known to a layman, except in a general way. A judge, however well learned in the law, may be but a layman so far as such matters are concerned. It is the duty of an engineer as a witness to educate him. He cannot know in advance what effect an error in records

may have in the final result of an action. He is therefore constrained to allow the utmost liberality in the examination of witnesses called to prove fundamental data. Until a tribunal is established, officered by men who are familiar with geological, hydrological, and other related sciences, we will continue to have protracted and costly suits involving water rights. Under present conditions, the wise thing to do is to accumulate the best data available; correlate it; put it in a permanent and easily understandable form; and then trust to luck that any lawsuits you may have will come before the observer dies, or is away without leave.

The author recommends that the legislature of the State of California be requested to declare by statute that records of water measurements made by water companies in the due course of business, in accordance with rules to be prescribed, disclosing diversion, distribution and utilization of waters, be accepted as *prima facie* evidence.

Improvement Requirements And Department Records

By C. P. Harnish and J. W. Ford

THE telephone on the desk of Bill Jones, Chief Engineer of the Blankville Water Company was ringing furiously. Breaking off his conversation with one of his assistants, Bill took up the receiver and found his pump operating foreman on the line.

"The pump in Valley Well No. 1 blew up during the night!" was the cheerful news greeting Bill.

"What happened?" he inquired.

"Well at six o'clock the operator saw that this pump was off the line and that it had stopped sometime during the night, since the storage tank was quite low. He checked the overload relays and found that they had kicked out. He reset them and found a locked rotor and motor. He called me at seven o'clock this morning. I went over, and after breaking the shaft loose by the use of a 36-inch Stilson, I found that there was a tremendous racket down in the well, indicating that something mechanically was wrong below the surface. The unit rotated freely under power, but would not rotate backwards."

"What did the noise sound like?" inquired Bill.

"It sounded like a lot of rocks rattling around in the pump column. The noise reduced in intensity in about two minutes after the pump started, but the longer it ran the greater the amount of vibration until the whole unit would move on the foundation block. The pump would not raise water to the surface of the ground."

"Okay," replied Bill, "That's enough evidence. Pull the fuses. We will notify the crew to come out and pull the pump."

A paper presented as a part of a symposium on the value of water department records, on October 27, 1939, at the California Section Meeting at San Francisco, by C. P. Harnish, Executive Vice-President, Southern California Water Co., Los Angeles; and by J. W. Ford, Superintendent and Chief Engineer, San Jose Water Works, San Jose, California.

This being attended to, Bill called for his pump file. The records showed that this was one of the older units, originally installed in 1927. The performance curve typical of pumps of this vintage showed a pump efficiency of only 63 per cent. The capacity against the operating head should be 1,000 gal. per min. The last test showed only 850 gal. per min. The indicated operating efficiency was down to 55 per cent. Looking at his production records in this district, Bill found a gradual but definite increase in demand. These records clearly indicated the need for more water at this location and that more capacity could easily be handled in the immediate distribution network. No trouble had ever been experienced with this well. The quality of the water was satisfactory and there was a very nominal drawdown. When originally tested, the well yielded up to 1,800 gal. per min. with a safe drawdown.

All this evidence was enough to lead Bill to the definite conclusion that a new pumping unit was in order and that repair (or the more probable complete overhaul) of the existing unit was decidedly impractical. Without further adieu, he wrote out the necessary performance specifications and turned them over to the purchasing agent's prompt attention, well knowing that within a safe time limit, the new unit with its greatly increased efficiency and capacity would be ready to do its job.

Hardly had this business been attended to when one of the assistants entered with the news that the City Engineer's office had just called stating that three blocks on Third Street were to be resurfaced, starting the following Monday morning on a W.P.A. Project. The maps showed this main to be 8-inch Matheson weight steel pipe, installed in 1926. Reference to the soil surveys showed that the soil in this particular locality was very easy on pipe. Further, the records showed only three leaks in the past two years in this particular section, and two of these could not be chargeable to any possible corrosive action on the pipe. The master plan showed that an 8-inch pipe was ample in this street.

The service record showed the three blocks to be about 65 per cent built up and the character of development was such as to expect very little additional growth in the immediate future. Calling the local accommodation office showed that no recent applications or inquiries for new services had been received on this street during the past year. Thus it appeared to be unnecessary to install any "blind" services to vacant lots. A fire hydrant at one of the intersecting streets was

still connected to a branch 4-inch line, so Bill took steps to have this immediately transferred to the 8-inch main. He now felt entirely safe in his own mind to let the City go ahead and re-surface the street, without his going to any expense except the small amount required for the hydrant connection.

Troubles in the water works business usually come in bunches and this seemed to be one of those days. Dr. Smith, the new President of the college in one of Bill's divisions, was next on the phone, and was very considerably agitated. It developed that 50 of his students were down with some form of mild intestinal sickness. The good doctor felt that surely it was the fault of the water.

"Just a minute, Doctor," replied Bill, "I have on my desk a report just received from our bacteriologist. This shows the water to be absolutely okay from all wells in your district, from the distributing reservoir and from two taps on the college grounds. These samples were taken day before yesterday. Further, I have similar results on tests run three days previously at the same locations and before that each week during the preceding month. Prior to that time our bacteriological records were absolutely clean as shown in semi-monthly reports back to the first of the year. Therefore, Doctor, it can't be the water. I suggest you communicate with your local health officer."

Bill could not help showing a broad grin as he hung up the receiver. This was a good one. Several years before he had noticed a similar outbreak among students at the college following their annual Halloween festivities. The first time this occurred it caught Bill a bit unawares and he spent a very anxious 48 hours while waiting bacteriological reports. The records, incidentally, had been in none too good shape, although he had never had occasion to question the sanitary condition of his supply. He and his good friend, the local health officer, had gotten their heads together over this incident, however, and had come to the conclusion that the outbreak was due to the action of liquids other than water on young stomachs unaccustomed to such beverages. Every year thereafter, for a month or so preceding the Halloween Season, Bill's bacteriological records have been complete and unimpeachable.

At home that evening with the day's work over, Bill could not help but reflect how different things were now than when he had first taken over this job some ten years previously. Then there were few reliable records to guide him in his decisions. The well records were

deplorable, and even those available frequently proved inaccurate. Pump records were worse than useless. While there were distribution maps of sorts, these were apt to be out of date and lacked much essential information. Then, when a pump broke down, or a paving project was planned, or when other improvements appeared to be necessary, Bill had to work very much in the dark. Such mistakes in planning as he had made during his regime he felt, for the most part, could honestly be charged to lack of proper data and records. All this had now been changed and by dint of hard work and the complete cooperation of all concerned, he had assembled records that constituted a firm base for improvement plans, as well as insurance that they would be adequate, but not extravagant. Thus, throughout the organization, there came to be reposed more and more confidence in Bill's judgment and respect for his decisions.

Some of the records which have proved so valuable to Bill Jones, and which are now so much a part of his scheme of things that he has to stop to think what they are, may also prove of interest to others charged with the grave responsibility of planning water works improvements.

Well Records Made

For example, to bring up to date his well records seemed of particular importance and so Bill made a systematic search of all the well drillers in that part of the country and uncovered logs of not only all the water company's wells, but many others besides which proved very helpful when planning new work. All new wells drilled are now not only accurately logged, but the various critical strata are described in some detail. Another practice now being followed by Bill, and some of his contemporaries, is the taking of chemical analyses of water encountered in the different strata as drilling proceeds, as well as noting the various positions of the water level. Such records indicate those strata most desirable for perforation not only as to quantity but also as to the quality of water expected.

All repair work on wells is also carefully recorded so as to show the difficulties experienced and the remedies used to overcome them.

To record carefully and accurately the water levels in all his wells, Bill has had some special cross-section paper printed whereon are plotted weekly water level readings of each well, both static and pumping levels. These charts have now been kept over a sufficient

period of years to present a very illuminating picture of the underground water levels in the entire territory served.

Since some of his supply comes from gravity sources, rain gages have been established at strategic points in the watershed area. Readings from these are carefully correlated with Weather Bureau readings in the general vicinity. Records of stream runoff are, of course, also carefully measured and recorded.

As in all water companies, analyses of the supply are made from time to time, both bacteriological and chemical. We have seen how having the bacteriological data readily available was a big help to Bill in one instance, so he has a permanent form for recording all bacteriological reports for each of the areas under his jurisdiction. This is valuable not only from an operating standpoint, but also clearly shows where improvements are required, such as chlorinating plants or other treatment facilities.

A careful record is also kept of all chemical analyses. Certain of these lend themselves to comparison which can best be illustrated graphically, and from these charts Bill has been able to plot his future course so as to keep his areas supplied with a gradually improved quality of water rather than the reverse. It has been necessary to abandon some wells as the water became gradually, but definitely harder, and others have had to be deepened. Some areas have to be shunned entirely for water development and others assiduously cultivated.

We have seen how in one incident Bill's pumping equipment records were valuable to him when a quick decision had to be made. This record keeping is of particular importance. It was not easy at first, but by hard work files were gradually built up to show accurately all pertinent data about the equipment in service. Performance curves of all pumping units head up the file of each plant. Bill's practice is to note thereon the results not only of the initial test run, but all others run subsequently. It requires considerable perseverance to keep a good pump file up to date, particularly if deep well turbine pumps are involved. These are apt to be pulled and overhauled every few years and definite changes usually made each time, which may be minor, or which, on the other hand, may be very important. Unless each such change is carefully noted and recorded, soon a comprehensive grasp of the pumping equipment situation becomes lost.

As in all carefully regulated businesses, Bill has paid particular attention to his production costs. He has his records broken down to show the amount of power or fuel used, as well as the costs. For electrically operated plants, for example, he has found it very useful to have a form of monthly report which shows for each plant the amount of kilowatt hours utilized per unit of water pumped, the average cost per kilowatt hour, and finally the average cost per unit of water pumped. These monthly reports are bound in permanent folders. While this information is invaluable from an operating standpoint, it also constitutes the base of operations from which all planning of water supply improvements start.

Bill finds it important to keep and preserve records of all repairs and costs of maintenance of pumping equipment which, together with the foregoing data, enable him to decide intelligently whether to make repairs on a particular piece of equipment, or to retire the old unit and replace it with new.

While there is no test like that of continuous performance, yet some useful operating data can be obtained only by specific tests run by technically trained men. Bill has found a way to record permanently these tests and to see to it that the test data are promptly and properly correlated with the production records. If a new man, for example, comes in and reports that by his test the efficiency of a certain unit is only 55 per cent, Bill can quickly square this with the monthly records, and if it doesn't square, the young man is promptly sent back to repeat his test.

Use of Consumption Records

Consumption as well as production records are necessary and can readily be obtained from the consumer billing department. The difference between total production and total consumption represents unaccounted for water. This gives some indication, particularly when it is possible to make comparisons between a number of districts, of the amount of water lost through the transmission and distribution system. At least these records indicate where further studies should be made of local conditions. Sometimes it is possible to avoid the expenditure of considerable capital to increase the water supply by giving suitable attention to stopping excessive leakage in the underground transmission and distribution system.

As to distribution system records, the first requirement, of course, is accurate maps kept strictly up to date. Supplementing the maps

should be an inventory of the distribution system showing a complete record of mains with the size and kind of pipe and dates installed, the size and kind of services, meters, and fire hydrants. A performance record of the distribution system is also of great importance. It has been noted how helpful it was for Bill Jones to know the condition of a particular portion of the system. It is very useful and informative to plat the leaks which have occurred in any given distribution system showing by different colors those which have occurred in different years. This shows at a glance those sections where replacements would seem to be called for.

Soil analyses are also valuable, not only in determining the type of pipe to be used for installations, but also to shed light on the performance of the pipe lines. Service and meter records are also important and should readily show the age of the service or meter and the effect of the water and soil conditions on the various materials. Flow tests should be made from time to time and records kept of these which would aid greatly in planning improvements to the distribution system. A very satisfactory method of making and recording these tests is used by the National Board of Fire Underwriters.

In this connection, pressure records are also invaluable and recording pressure gages should be set at various portions of the distribution system and the charts from these carefully noted and preserved. It is helpful to show thereon what pumping plants were operating.

In making a rather comprehensive study of a distribution system recently, it was very essential to know the demand in various portions of the system. A quick way of determining this was to outline on a map the boundaries of each meter reading route, some twelve in all in this particular case. Within the boundaries of each route there was shown the number of consumers therein, the total water consumption for the maximum month, the percentage that this route showed to the total, and then this percentage converted into gallons per minute of the maximum demand. It was assumed in this case that consumption in the maximum day and the maximum hour bore the same relationship between districts as did the maximum month, and Bill Jones even dug up some records to prove this. This study gave quite an illuminating picture and clearly indicated where enlargements to the distribution facilities would be most effective. Most water companies cannot spread their ammunition too far, but in making capital improvements must concentrate on those areas

where improvements are really needed and where the money spent will be effective and economically justified.

From time to time everyone who has to do with planning improvement for a water system has occasion to make some studies or computations. These may run from very simple calculations having to do with the buying of a pump of a proper kind, up to an elaborate and intricate hydraulic study. It is essential that all these studies be properly recorded. In fact, when any engineering decision is made having to do with the installation of some improvement, the basis for this decision should be a matter of record. We may be very sure that Bill Jones placed in his pump file a memorandum showing how he happened to choose those certain head and capacity specifications for his new pump.

One could very easily become careless in this regard and there also may occur the opposite fault, namely, to clutter up files with a lot of rambling data and calculations that had largely been superseded and had very little bearing on the real decision. Engineering computation records to be of any value in the future should be neat, compact, and properly indexed. Then they may be of inestimable value when most needed.

It is always a good idea when a case is closed, or more or less permanently suspended for some reason or another, to then correlate all the data that has been collected while it is still "hot." A little time spent in doing this will often save itself many times over and make it possible at some future time to pick up quickly and understand the work that has been done previously, perhaps by someone else.

Record keeping can of course become a fetish and the costs run up far beyond the proportionate benefits. Many water companies, however, seem to err the other way. They either do not keep nearly enough records, or else those that are kept are poorly kept. Whatever records are worth keeping in each particular situation are worth keeping well. Finally, as far as Bill Jones is concerned, now that he has been brought to think about it, he feels quite sure that his diligence in collecting these records, preserving them, and then consulting them carefully (and sometimes even prayerfully) before making important decisions, has been a big factor in such success as has come to him.

Department Records for Supply and Distribution

By Howard A. Harris, Jr.

PLANT operation requires about 75 per cent of a water works superintendent's time and thought. Therefore anything which will save him any part of such time and thought is of very definite value. We believe that proper records will result in a saving of these efforts.

We must first consider what types of records are to be kept so that the greatest value may be obtained. It is not necessarily true that the greatest volume of records will result in the best records.

For the purpose of the discussion the keeping of records is divided into the following:

(A) Intake and pumping,

(B) Purification, including pretreatment and filtration,

(C) Distribution system.

Each of the above will be considered separately, although each is related to the others.

(1) *Water Produced.* Water is our only finished product and it is essential that it be properly inventoried. The records of water production should be kept in such manner as to show (a) total production, monthly and annually; (b) average, maximum, and minimum daily rates; and (c) maximum and minimum hourly rates.

This information is required in order to plan the operating schedule for pumping plants or other sources of supply, to balance the quantities pumped directly and those withdrawn from storage on peak demands, and to regulate the amount of chemical treatment. This information is also needed to make it possible to check unaccounted for water in the distribution system, to make comparisons from year to year of production costs, to show the trend of system demands and necessity of developing new sources, and to show relative productivity

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of different sources and relation of water demands to rainfall so that estimates can be made of what may occur in an unusually dry year.

(2) *Power Consumption.* In a large number of water systems power for pumping is the largest single item of operating expense. The following records relative to power consumption are required: the total kilowatt hours consumed, the maxmum demand, the power factor, the cost of power, the cost per kw.hr., the cost per million gallons and the quantity of water pumped per kw.hr.

These records are necessary for a continuous check on efficiency of the pumping equipment, for planning the most efficient combination of pumps, for checking power schedules to determine whether the plant is being operated on the most economical one, and for seeing that operation is held as nearly uniform as possible in order to hold down maximum demand charges. Several years ago a large storage tank was installed in one of the California Water Service systems. Records proved that after the installation of the tank the average pumping cost was reduced 50 cents per million gallons.

(3) *General.* Some further records which are very necessary are: load factor, pressure maintained, water levels, shutdowns, etc.

Load factor records tell us whether the various plants are being used properly in the distribution of the load. Records of pressure maintained at the source of production are required in order to know whether or not water is being delivered into the distribution system at a satisfactory head. In water systems using wells as a source of supply the records of static and pumping levels in the wells show whether pump settings are deep enough and whether wells are being overworked. Records of shutdowns with their causes enable the operator to determine steps to be taken in order to eliminate such shutdowns as far as possible.

The discussion of records for purification, including pretreatment and filtration, will be presented by Mr. Hoskinson in the paper immediately following this one.

(1) *Plat Maps.* Plat maps of the entire system should be available on a scale sufficient to show location, size and kind of all mains, size and location of valves, fittings and hydrants (scale 1 in. = 100 ft.).

(2) *Service Records.* These should consist of a card file, giving the location, size and kind of each service and also its date of installation. If deemed advisable the service records may be kept on the plat maps showing the mains.

The value of good maps of the distribution system is obvious to all superintendents. When a shutdown is necessary for making a

tie-in or repairing a major leak, it is necessary to know the location of all valves to be operated. This information is also needed in connection with flushing programs. The specific location of the main is needed when services are to be tapped on it or tie-ins made to it. This information is also required by contractors or other utilities doing work in the streets.

(3) *Meters.* A record of individual meters should be kept showing the age of the meter, years of service rendered, repairs made and test data. These records consist of two parts, first meter history and second, meter test data. Meter history should be maintained in a card file system with a separate card for each meter. Meter test data should be on sheets approximately 11x18 in. and provide for 25 to 30 tests per sheet.

Meter records are essential in the operation of any kind of meter testing program. This information is also very helpful in convincing governing bodies and consumers of the general dependability and accuracy of a water meter.

(4) *Recording Charts.* These should be kept of water levels in tanks and reservoirs showing hourly drafts and refills.

The continuous record of levels in tanks and reservoirs is required in order to know if total available supply during peak is sufficient and whether or not the load is being properly divided between storage and direct pumping and if the plant is making the best use of its storage. It is also desirable to know the minimum reserve available in storage at all times.

(5) *Pressures.* Records should be kept of pressures at sufficient points throughout the distribution system so that a general picture of pressure conditions is available at all times.

The record of pressure throughout the distribution system is required in order to know if reasonable service is being rendered. Also, such a record shows whether changes in operating methods such as zoning off certain districts, diverting water from one pressure zone to another, etc., result in an improvement or detriment in general average service. Pressure records are very helpful in case of low pressure complaints, resulting often in tracing the cause of trouble to consumers' piping, but also often locating mains or service pipes no longer large enough to render proper service.

(6) *Complaints.* A record of consumer complaints showing the date, location, nature of complaint and action taken is of great importance.

The record of complaints is very essential to making proper ad-

justments in treatment of water, flushing of mains and services, repairs to meters, operation and maintenance of pipe system, and advice to consumers relative to operation of or replacements to a portion of facilities located on their own property.

(7) *Flushing.* A record should be kept of the systematic flushing of the system, showing the location, time and duration of flushing and the results accomplished.

This record is needed to show whether or not the flushing program is accomplishing the desired results and what changes should be made to obtain better results. With proper flushing records the cost can be determined and balanced against the cost of such treatment as would reduce the flushing being done.

(8) *Fire Reports.* A record of all fires with data on suction and discharge pressure at pumpers, number of fire streams, duration of fire, etc., is very necessary in case of later discussion with officials regarding the adequacy of water supply at the fire.

(9) *Maintenance.* A complete record of maintenance of equipment and structures is very desirable. These records are important from several standpoints: first, in order to have a definite maintenance program; second, to have a complete record of maintenance cost on various types of equipment and structures; and third, to make comparisons between various types of maintenance materials used for identical purposes.

(10) *Special Surveys.* Records of special leak surveys, electrolysis studies, etc., should be preserved for future use. These studies have a very direct bearing on the cost of operating and maintaining the water distribution system. Leaks, of course, result in serious loss of water, the product we have for sale, and therefore must be kept at a minimum at all times. Electrolysis may result in damage to pipe structures with resultant heavy maintenance expense, and steps must be taken to eliminate such damage.

It should be stressed that all charts and records should not be merely collected and filed away but should be thoroughly studied to ascertain what may be learned from them.

We think it will generally be agreed that all records which will result in a saving of operating time and expense are very necessary. The problem is to determine what records are included in this class. From our experience the records which have been suggested will all pay dividends to the water works superintendent in time and expense saved in his plant operations.

Treatment Records and Their Value

By Carl M. Hoskinson

A WATER plant without an adequate record system has about the same chance to succeed as a five-and-ten-cent store without a cash register. Wherever and whenever an investigation is launched to find the cause for a certain effect, the first step is to secure the underlying facts in the case. When facts are desired, the human memory is recognized as being notoriously fickle and untrustworthy, and written records are first sought, which when dated and signed at the time taken, furnish the strongest evidence of past occurrences known.

It is a well recognized and undisputed fact that proper pretreatment, purification and sterilization of water are accomplished only by close laboratory control by trained men specializing in this work, and complete continuous records of all steps in the involved process of purification are necessary to serve as a background for a constant effort to improve operation and reduce operating costs. The obligation of a corporate or municipal water department to serve a safe supply of water to its consumers has been recognized in numerous court decisions and the liability of the department for lack of care resulting in spreading of any water-borne disease such as typhoid, which breaks out only after a definite period of incubation of about two weeks, can only be definitely established or disproved by carefully recorded and preserved records of every step in the purification processes. Thus it is seen that the value of laboratory control of purification is dependent on the minute records of all steps in pretreatment, filtration and sterilization processes.

The preparation of water for filtration is vital to plant performance, as application of coagulant, coagulation and pretreatment processes

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A paper presented as a part of a symposium on the value of water department records, on October 27, 1939, at the California Section Meeting at San Francisco, by Carl M. Hoskinson, Chief Engineer, Division of Water, Sacramento, California.

and sedimentation prior to filtration accomplish approximately 80 per cent of the work of purifying and clarifying the water before reaching the filters, leaving the filters to do only about 15 per cent of the work of purification and bacterial removal, and the final sterilization by chlorine being represented by about 5 to 10 per cent of the total process. Adequate preparation for filtration is a vital function of laboratory control as filters will not function if called to do more than their share of the total job of clarification and bacterial removal. Sterilization chemicals would be wasted if used on bacteria which should have been removed in the earlier processes. Imagine the predicament of the superintendent or chief chemist in attempting this preparation of water for the consumer without recording every step in the laboratory and treatment control so that he is certain that all steps in the process are in proper proportion and sequence and unite to form a harmonious whole.

Among the principal objectives attained by the careful compilation of complete and adequate water purification plant records are listed the following ten items:

(1) Complete knowledge of the hour to hour efficiency of the plant with complete information on the quality of the finished product.

(2) Ability to exchange information with other plants on any or all steps in the purification processes.

(3) Indices of the degree of perfection of the purification treatment, as basis for "scoring" of a plant's position in comparison with other plants in national or international ratings.

(4) Check on the efficiency of laboratory technique and degree of proficiency attained by the operators.

(5) Setting of certain standards of quality which are dependent on the degree of perfection attainable as shown by operating records. All records made help in establishing official standards for water analysis and treatment and also indicate any shortcomings in present standards and need for further data which must be derived from operating records.

(6) Cost analyses of details of operation and check on possible costly leaks in plant processes.

(7) Check on operation to refute or substantiate any consumers complaints on water quality. The complaint of a consumer on quality of water is usually from some fanciful notion that he "tasted chlorine" or noticed a "peculiar odor" or that the goldfish were not doing well. Of course all such complaints should get a thorough and

sympathetic investigation which usually will disclose nothing wrong and the consumer will be pleased that his complaint has been investigated and some correction made (often only in his imagination), but when, as sometimes happens, some action must be taken and quickly, the records should show at a glance whether anything was wrong in the plant operation.

(8) Complete information on the raw water which must be treated, with particular reference to its biological, bacteriological, and physical condition, which information may be readily compared with previously recorded data on the same water and any change in treatment technique decided on without loss of time or danger of passing on an unsatisfactory product to the consumer. In this connection, records of application of chemicals for coagulation and sedimentation are important to the pretreatment operator, particularly when taken, as they must be, in relation to laboratory tests of the raw water, including physical tests such as turbidity and algae determinations, and chemical tests such as degree of alkalinity and total hardness. Raw water records will show when aeration is needed, also time when treatment for taste and odor elimination should be started. Records of the treatment for taste and odor removal, when applied, quantity used per million gallons, rate of stream flow, algae condition, and temperatures of air and water will be valuable at future times when meeting similar conditions.

(9) The tendency of the plant output to cause corrosion or scaling in ferrous pipes or vessels or boiler tubes. This item is important and plant records should be complete on this point as well as records of corrective measures which may have been used and results obtained.

(10) Finally, and most important, is the knowledge that the plant is producing either a sterile product or one well within the allowance of the Public Health Standards. In this connection, records of chlorine application are particularly important; also records of bacterial counts and coliform index of the water through the various stages of treatment are absolutely essential.

Report on Purification Data and Forms

The value of reports and records is greatly enhanced by uniformity and conformity to a standard so that comparisons may be made with other plants operating under similar conditions. The "Report of the Committee on Purification Data and Forms," of which James W.

Armstrong was Chairman, indicated that an exchange of record forms and a certain amount of standardization of records for plants was desirable as a check on efficiency and cost of operation. This Committee recognized the impossibility of the use of a "standard form that would meet the needs of every city as each city finds it desirable to record certain data which would be of no particular value to other cities, but in order to compare the work of one filtration plant with another, it is very desirable insofar as possible, that each city preserve the same order in making reports." It was stated that "standardized forms are particularly desirable in permitting a detailed comparison of one filter plant with another on a day to day basis and the trend of filter plant performances can then be seen at a glance. If reports are exchanged with other cities and their results are similarly plotted, comparisons may be easily and definitely made. Each step in filter plant operation can be compared in a similar manner." The Committee felt that reports of monthly averages of operation are of little value in comparing plant performances and recommended a certain form for recording of purification data. Mr. Armstrong long since noted that a detailed uniform monthly report arranged for easy interpretation served the double purpose of providing the operator reliable data for checking his plant performance against his own past records and also of allowing him to compare his plant with others. The studies of Mr. Armstrong and the Committee indicated that "reports should be made in sufficient detail each day and recorded in such a way as to permit each step in the sequence of plant operation to be easily compared with other steps in the purification process and to be studied independently." When so made they become very useful in comparison of operation between plants. The type of monthly report which has been developed to be of the most value, includes a whole month on one sheet with a horizontal line completely across the page for one day of operation. On such a report form the one horizontal line contains all the essential data covering one day of operation and the vertical columns each contain a monthly record of the subject indicated at top of column. This arrangement makes it easy to study the entire record of plant performance and to check quickly on any unusual condition. Mr. Armstrong long ago used this type of report at Baltimore and this type has also been used in the laboratory of the Sacramento Filtration Plant since the plant started operation in 1924 and has been found very satisfactory.

Continuous shift records, preferably made at least hourly are important and valuable because they give the operator information

on what is going on at the time it occurs and enables him by a quick survey of the record to correct any irregularities in operation. Records must be in such form as to be easily interpreted by any operator. Records made by recording instruments should be read at least hourly and preferably logged by the operator so that he may be sure to catch the significance of the reading without delay and take any necessary steps to correct any operating fault. The test of any system of records is its adaptability to profitable use in making ready comparison of any part or unit of the plant with that of any other part. This involves careful recordings so that comparisons may be made on an hourly, daily, weekly, monthly or yearly basis. A system, to be useful, must make record of all important items of operation of a plant, and all records must be neatly tabulated so that the original may be the permanent record. It should not be necessary to make copies of records except for some very special need and they should be kept on permanent file in safe locations in the plant for future reference. Without a proper record system the operator can have no intelligent idea of what he is doing and if the operator does not know what is going on during his shift, it certainly follows that the chief operator, the chief chemist, the chief engineer and the superintendent will need more than the allotted human senses to guess accurately at a later date what has transpired.

Records of physical condition of equipment, dates and nature of repairs, materials used for repair and reasons for replacement of materials by dissimilar materials, are very useful and serve as a valuable background for future maintenance work. In this connection the records of the use of various metals and other materials, how applied to the work, and reasons for making the change are very valuable. Uses of non-ferrous metallic repair materials and their application and records of service should be recorded, as the record of this repair work is far too often left to the memory of the engineer or mechanic doing the work. It is believed that greatly improved operation might result from an exchange of repair information on plant equipment. We have known of such information being particularly useful to a certain manufacturer of hydraulically operated gate valves. Shift operating records may be particularly valuable to indicate the need for repairs to plant equipment before serious trouble develops.

Records of protective coatings of all kinds applied to metals and other materials for their protection against recorded corrosive or abrasive conditons should be carefully kept and more general candid

opinions and information should be exchanged between all members of this Association so that all may learn through the experience of others the best protective coatings for all conditions met by each member. For this purpose a standard form of record might be developed to cover all the conditions under which the protective coatings were used, including dates of application, type of duty, nature of exposure, purpose of treatment, treatment replaced, and continuous service records. It is believed that such an exchange of information between members would be of great value and would result in very material savings in proper use of protective coatings for various applications.

The need for collection of national water works statistics and of comparative data is well recognized but as yet there has been no adequate or complete compilation of all the data needed and this fact may be traced back to the lack of realization of the need for basic records and data on all the operating details of all of the water plants in the country. Unless we keep complete and accurate records of all of our operations we will not be able to cooperate in furnishing the needed information for the compilation of complete national statistics, which when accomplished, will be of great value to all in the water works field.

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Public Relations and Department Records

By H. Buford Fisher

BRINGING a river to a city is an engineering problem of the highest order. Carrying the message to the people of the value of such a project and system is a problem in human engineering of the first magnitude. Some call this latter problem public relations, some institutional advertising, some promotion, others propaganda, and still others by various names good, bad, and indifferent, depending on their viewpoints. By whatever name it is known, the goal is the same—the favorable acceptance of the organization in the community resulting in public support and cooperation based on consumer understanding and interest.

We hear a great deal these days about public relations and employee relations. The two dovetail together in such a way that it is impossible to consider one without including the other. This picture, as it concerns a given industry or utility, is changing rapidly due to new methods and techniques of handling the problems which have been brought about by economic and industrial conditions and the regulations which have been the outgrowth of these conditions. Whether or not we are directly or indirectly affected by these regulations, we must concern ourselves with them and conform where necessary to keep in step. A sound but flexible program of public and employee relations must, therefore, be developed and maintained if we expect to achieve our purpose. This can be accomplished in no other way than by feeling the pulses of the people we serve and our employees who serve them, and obtaining their reactions to the programs installed. Accurate records of these reactions give a clear and concise view in that they permit one to obtain an accurate

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A paper presented as a part of a symposium on the value of water department records, on October 27, 1939, at the California Section Meeting at San Francisco, by H. Buford Fisher, Personnel Manager, East Bay Municipal Utility District, Oakland, California.

cross-section of public opinion rather than one that may be purely localized.

In keeping with the season of the year, the development of a public relations program might be compared to the modern methods employed in the development of a football team. The general manager, the spear head, is the head coach who must coordinate the play and decide on the strategy. His staff represents the assistant coaches who are assigned to the various phases of public relations and who must be thoroughly versed in and know well the problems involved in their various fields. These men must be able to direct properly the efforts of the players, the employees.

The recognized major job of any football coach and coaching staff is to develop team play, loyalty and good sportsmanship and certainly this applies equally well to business. Nowadays in football it is the telephoto film, the scout and the statistician that have almost as much to do with winning games as an alert and aggressive team. These visual and tabulated records aid in diagnosing weaknesses in team play, and developing essential defensive as well as offensive plays. Flaws in a public relations program are readily determined by public relations audits, employee contacts, friends and critics and from these the strategy is developed to overcome any weaknesses whatever may be their cause.

A young man visiting the Smithsonian Institute observed the exhibit of dinosaurs in his travels and inquired of the guide, "Who shot these animals?" The guide quickly responded, "Nobody, the weather changed." We have to be careful that the weather does not change on our public and personnel relations programs and this will happen if we do not adapt ourselves to changing conditions.

In order to illustrate the development of a public relations program and the part and importance that records play in it, the author will outline the East Bay Municipal Utility District's plan and comment on each phase of it. This is a representative program, one with which the author is familiar, and one which has been simply carried out in an educational way without hurrahs and flagwaving. It is also felt that most people are interested in practical ideas that have proven workable rather than in generalities which is another reason for confining the paper to a definite program.

The program logically divides itself into three parts, each of which ties in with the other two, and all of which involve planned record keeping. The first and most important is personnel which covers the

handling of applicants, the selection and training of employees, and the making of pleasant consumer contacts. The second is visual education or the stimulation of visual reaction through the appearance of plant, property and equipment and the third, publicity, the use of the printed word in newspaper releases, publications, and in the comments of other organizations regarding the utility.

The District's public relations program is based on the major premise that "seeing is believing," or better stated as it relates to consumer-employee contacts that "actions speak louder than words" and, secondly, that the records kept do not exist for themselves alone but reflect what is being done in the program, and thirdly, that truth in the advertising and selling of the utility pays, misstatements or camouflage of facts only serving as boomerangs.

Value and Details of a Personnel Program

A good personnel program is the most essential factor in a well functioning public relations program. Applications, interviews, examinations, employments, classifications, personnel records, vacation and sick leave privileges, service and disability pensions, accident prevention, in-service training, salary advancements and other recognitions are not just terms but are a part of any well planned personnel program. The development of the District's personnel work has covered a ten-year period and is not complete nor will it ever be if we expect to keep it alive. The primary purposes of the plan are to bring about fair and equitable dealing with employees; to reduce favoritism and endeavor to eliminate it; to offer job security; to recognize service well performed; to provide for sickness, permanent disability and old age; and to secure the loyal support of the employees which is done in part by giving them a voice in the program with two members of a board of five on the Retirement Plan, and the privilege of a hearing on all changes in civil service rules and regulations.

The civil service system operates as a division of the organization under the general manager. This system calls for advancement by promotional examinations, the serving of a probationary period on each assignment, and a careful follow-up on each employee. All of this requires the establishment of a complete record system, which gives a personal history of the employee, his accident record, his advancements, his examination record, his ability to serve in other capacities, etc. Interviews and personal reactions of division heads

must be a matter of record as they concern employee relations. The pension, personnel, and safety records of each employee have been centralized to give quickly a complete picture of the individual.

As good personnel relations, the pension plan, civil service, adequate leave, anniversary awards of gold service pins, and wage and salary increase on anniversary dates are incorporated in the program. In addition to these, after each promotional examination, employees are called into the personnel office and their examination papers reviewed with them. Notations regarding these interviews as well as the examination interview are made a matter of record.

The care in the selection of an employee would be for naught unless there is a follow-up on the employee's work and the time spent in instructing and training him. There's an old saying, "you can lead a horse to water but you can't make him drink." No one can force or compel an employee to take a training course and expect good results. There must be an interest stimulated in the employee to participate, especially if the course is outside of office hours. Since the advent of civil service in the District, there has been a marked increase in the number of employees enrolling in night schools and other educational institutions. Employees have learned that if they wish to advance they must be prepared. As a result of this increase in interest, the Employees Association is working on a plan for conducting educational courses to which the management is lending its support.

Considerable time during business hours is spent on training new employees as well as employees transferred to new positions. This gives them a background in the work of the division in which they are employed and its relation to the other divisions. The training is carried on for the most part informally since employees as a whole are not predisposed to formal training. Most new employees in their desire to make good are interested and willing to spend time in preparing themselves for their assignment.

A further employee education program of "seeing your utility is knowing it" has been established so that key employees who come in contact with the public as well as other employees are taken on visits to main storage reservoirs, filter plants and other features, as well as being shown the motion picture "The Story of Water." In each case a talk is given by some one well versed in the feature visited and every phase is explained. Most of these visits are made on company time.

The employee magazine, "Splashes," published in printed form regularly on the twentieth of each month, records the activities of the employees and the District. Both employees and management share in its editing. Personals, sports, and social functions are submitted by the employees. In the articles and pictures, a special effort is made to include all employees regardless of rank. To accomplish this, a card record is set up and carefully maintained. The management's part in the publication includes educational articles on the operations of each division, written by the heads of the divisions, as well as items on civil service, the retirement system and safety. A properly functioning editorial staff with the necessary correspondents aid in making the employees aware that the magazine is theirs and that it is designed so that they may have a part in it.

Service with the District is recognized through the award of an appropriately designed gold service pin symbolic of the District's operations. As the employee completes each five years of service, he is called into the office of the general manager and receives his award. This method of presenting service pins gives the employee an opportunity to sit down with the general manager and discuss his (the employee's) own problem. It also aids in establishing the open door policy of management. Back of all this is an accurate record used in awarding pins set up both chronologically and by employee. Thus the plan is automatic in its operation.

We have heard it said "a man is judged by the company he keeps." The reverse of this is also true—which means in short, that each and every employee is constantly under observation by the general public and the organization as a whole judged by their individual actions. Each employee reaches a certain group of people in the community and his treatment by the District and his ability to answer properly questions relating to the District reflect the type of organization with which he is connected. This is particularly true of employees who take an active part in community affairs. All types of training, therefore, are a very vital part of any public relations program. District employees are active in practically all service clubs, professional organizations, and Community Chest agencies as well as church, lodge, and school groups.

The Employees Association aids in public relations work by its part in civic affairs. The association along with those of other business concerns takes part in inter-company athletic competition through membership in the Industrial Athletic Association. The

association performs an excellent service in employee relations through the educational, social and athletic activities which it sponsors in the organization.

The employee-operated Credit Union with assets of over $75,000 renders a useful service to the employees both individually and collectively by taking care of their provident needs and in encouraging thrift. Over 60 per cent of the employees participate either as borrowers or as depositors or both.

A good safety program means a great deal from both a public and personnel relations angle in addition to other considerations. Reduction of automobile accidents and public liability accidents in which the public is involved eliminates considerable grievance and aids in the maintenance of good will. Employees are recognized by safe driving awards, for lengths of service without an accident. Other steps are taken to promote safety and vitalize the program. These changes made from time to time in a comprehensive plan stimulate interest in the work. Records are also the backbone of any worthwhile safety program as they aid in visualizing weakness in the methods employed.

Contacts with the Public

Proper consumer contacts are the life blood of any public relations program. From the general manager on down through the ranks these contacts must be properly handled if public good will is to be maintained.

There is, perhaps, no place in a water utility where a good public relations program may be so easily upset as in collection, service, and adjustment work. Here the importance of selecting employees who are capable of handling this type of work and enjoy doing it cannot be over emphasized. Tact, fairness, and patience in dealing with the public are essential employee qualifications for this type of assignment. This to a lesser extent is also true of meter reading.

The collector-servicemen handle all field inspections pertaining to complaints on high water bills while the inspection division handles all complaints dealing with pressures, quality of water, and the more technical matters. All types of inspections are completely recorded on forms prepared for the purpose and are filed so they may be reviewed prior to future inspection of the same premises. All consumer complaints for which the cause is not definitely known are immediately investigated, proper corrective measures taken and the

consumer advised of the findings and results obtained. This latter is usually accomplished by letter. Meter readers note unusual condition such as increases or decreases in a consumer's consumption and record these on their meter sheets. They also make a casual inspection of the premises and the consumer is told of the condition. When necessary, the meter reader requests that further inspection be made.

Through the records of complaints and inspections important information has been obtained which aids in the public relations program by bringing about changes in the District's policies which have irritated consumers. There has been a change in the methods of handling delinquent accounts in order to bring about the minimum of consumer complaint and at the same time maintain collections. The extension of the credit period and the allowance for discretion on the part of collectors and adjusters in order to lighten the consumers' burdens has been an additional good will builder. The value of this policy is shown by the fact that in the most trying times the write-off of accounts as uncollectible has been less than $\frac{1}{3}$ of 1 per cent of the gross revenue billed regular consumers.

Formerly when the District shut down mains or services for repair or renewal the employee in the crew who could best be spared was assigned to the task of informing the consumer of the shutdown. Experience has shown the value of selecting the best men in the crew from the standpoint of dealing with the public. This has proven of considerable value in further establishing good will and reducing complaints from this source.

Even though no opening exists for employment with the District, an applicant does not find a "no help wanted" sign greeting him. He is given an interview in which the employment situation is explained to him. If he desires, he may file an application for temporary appointment and a request to receive notice of civil service examinations. A brief record of the interview is recorded. Unsolicited comments on this proceeding have been extremely favorable.

The District in line with the slogan "seeing is believing" has devoted considerable time and thought in conceiving and developing the visual phase of its public relations program, to show the public what goes on in back of the faucet. The principal feature of pictorially presenting to the public their water supply system has been an informative sound film. This was developed through various stages of projection starting with stereopticon slides, then a silent film photographed, titled, and assembled by three members of the

District's staff, and finally the sound film entitled "The Story of Water" professionally made at a moderate cost. The film portrays the history of the project, the storage transmission and distribution of the water supply and the uses of water. The success of the presentations of the film has lead to the decision to produce another sound film in Kodachrome dealing with the protection of the water supply.

Arranging Movie Presentations

The film "The Story of Water" has been shown to over 100,000 persons in the East Bay area. Several prints of the film have been loaned to the school departments and to the University of California. The film has been especially designed for service clubs and classroom programs and, hence, has been timed for a 23-minute projection.

Presentations in which the District's sound equipment was used, were first arranged through District contacts with service clubs, etc. However, we are now receiving numerous requests for engagements. The management, staff, and others were called in during the development of the picture to give their ideas of the anticipated public reaction to the sequences and script. At each presentation, a speaker from this same group is present, who gives a short preliminary talk outlining the aims, and progress of the District, how it functions and what has been accomplished. After the picture has been shown, questions are invited from the audience and every effort is made to acquaint the consumer with his water system. This plan has placed thirty of our key people before the public. Having an excellent background for the assignments, they are recognized and accepted as men who know what they are talking about and, hence, are in a position to answer technical as well as non-technical questions. This has tended to give a more personal presentation of the District's film. Incidentally, it has permitted the employees to obtain an insight into what the public is thinking about the District.

In connection with the problem of records, all engagements are recorded on individual cards which give the name of the organization to which shown, officers, location, membership, attendance, District speaker, and his comments. At six-month intervals these cards are summarized.

Every engagement is confirmed by letter announcing the speaker for the program and setting forth a brief description of the sound film. These confirmations have resulted in numerous special an-

nouncements appearing in organization bulletins, which have reached many times the number to whom the picture has been shown and have resulted in favorable newspaper publicity and articles on these civic group programs at which the film is shown.

Exposition Exhibition

Another fertile field for developing community interest has been covered with well planned educational exhibits at Health Shows and Housing Expositions, and more recently with an exhibit at the Golden Gate International Exposition. These have been demonstrations of actual operations featuring the protection of the water supply.

The District's exhibit at the exposition consists of a colored relief sketch map of the entire system, and colored photographs of special features. An attractive model filtration plant complete in every detail has been in constant operation since February. This shows the various steps in filtration, namely, aeration, coagulation, sedimentation, and filtration as practiced in a modern rapid sand filtration plant. The model, which is 10 ft. long and stands $5\frac{1}{2}$ ft. high is electrically operated and each phase of the purification process is shown by the use of plate glass basins, chrome framed, which permit every step to be viewed in detail. Newspaper articles and special comments have resulted from the exhibits.

Either key District employees or trained attendants are in charge of the exhibits. Daily attendance records are maintained and special and general comments and reactions of the public noted under a special heading. These records are proving extremely valuable in analyzing and revamping the public relations program.

Recent innovations in the visual program have been the use of artistic photographs properly arranged and mounted which are titled and described in neat printed form. Many of these have been and all are now being hand colored with oil paints. The photographs are set back to back in well designed chrome frames and placed in the windows of the business offices. The attention and favorable comment these have received are ample proof of the value of the program.

Records are maintained in order that the pictures may be rotated at regular intervals among the various offices. Large colored photographs with appropriate framing have been placed on the walls of each business office where they may be viewed by the public.

Along similar lines, an automatic slide projector assembled in an

attractive cabinet is being used to project titled slides of the water system in natural color on a daylight glass screen. The projector gives a continuous showing of 48 slides displayed at 12 second intervals. This equipment which can readily and easily be transported has been used in the business offices and at the Exposition and will be used elsewhere from time to time.

Cleanliness and Beauty

It has been said that cleanliness makes for confidence; beautification for prestige. The importance of this statement has been recognized and considerable pride results in the spic and span appearance of District plants, building grounds and equipment. Pumping plants and structures have been designed and constructed to harmonize with the particular residential areas in which they are located. The type of structures and the beautification of the grounds by well planned landscaping has built good will where resentment might easily have developed, over the construction of a plant. Many of the larger plants have unusually large areas given over to flowers, trees and shrubs. To enhance further the appearance of all structures, attractive new signs are being designed and will shortly be installed.

The public is invited to visit the plants through District bulletins, speakers at film presentations, and special announcements. Many have taken advantage of these offers, especially organizations and school and scout groups. The plant superintendents or sanitary engineers conduct these tours and explain each phase of the operations. At the main storage reservoir on the Mokelumne River, picnic grounds with the necessary facilities are available. Large groups numbering as many as 500 persons have made this trip to the Pardee Dam. Educational trips have also been arranged for community leaders.

Another program which has been rapidly carried out has been the planned replacement and revamping of all automotive equipment, with considerable thought being given to foreman trucks, service trucks, and special equipment. These now have assumed an extremely businesslike appearance, provide a safe and protected place for crews traveling from job to job as well as making available storage space for equipment and supplies. Care is taken to keep every piece of equipment as clean and neat as possible at all times.

Good housekeeping on the job is an asset to any organization and

results in the least irritation to the public. Thoughtfulness is exercised in seeing that small excavations are properly and safely filled, that consumers' sidewalks, dirty as a result of construction work are clean at the end of the day, and kept in order during the day, and that consumers are not inconvenienced during a period of construction. These and other courtesies have been found to require little time and they mean much to those on whom we depend; hence, considerable thought is given to them. Some of the irritations to us may appear trivial but to the consumer they stand out like a sore thumb.

Printed Publicity

One of the several ways of informing the public as to the aims and operations of a utility is through the newspapers published in the area served by the organization, through publications of the utility itself, and other similar means. This brings us to the third phase of the public relations program, the use of the printed word. Here too, as will be pointed out, the phrase "seeing is believing" is also carried out by including whenever possible photographic illustrations.

The statistical records of all departments are contained in a volume entitled "Statistical Data." This is prepared every fiscal year and with the department reports serves as the basis for the preparation of the printed annual report of the District, an accurate, pictorial, statistical, and written report of about 100 pages which forms a permanent record of the activities of the organization. These reports serve as the basis for special progress press releases regarding the growth of the District and the East Bay area; monthly reports by the General Manager to the Board of Directors serve to prepare progress reports on activities of interest to the general public.

It was Sir Harold Bowden who made the statement "Facts that are not frankly faced have a habit of stabbing us in the back." This is certainly true of hastily prepared press releases in which the material contained therein is not reviewed; hence, great care is taken in preparing, checking, and approving all official District releases.

Due to the cooperation given the newspapers, excellent coverage is received by every paper in the area. Additional publicity is given the District by special yearly coverage in the development and automobile sections of the leading dailies, in the year books of these papers, and through editorial comment.

A new series of releases, which is proving quite popular and receiv-

ing good coverage, is one of human interest stories written around District employees as well as unusual types of equipment used by the District. These are headed "Wonders of the Water Systems." Some of the titles give an inkling of the general nature of these articles: "The Machine That Arrests Electrical Vagrants," "The Fireman with the Largest Territory," "The Machine that Radios the River's Flow," "The Sun Drinks Water, Too," and "New Forests for the Watershed."

Use of Simple Language

We are aware that the average citizen does not understand logarithms, electrolysis and other highly technical terms. Therefore, articles intended to reach the general public have to be stripped of all technical expressions and couched in simple understandable language. The articles referred to represent a definite move to do just this by popularizing the story of the people's water system.

Mats are furnished the newspapers for these articles and on all other releases where they would prove of interest and fit in with the article. The main daily papers, however, are supplied with photographs. Recognition is also afforded the District by large special adds of other organizations in which the District's water supply system and its service are featured. This involves the availability of records for promptly furnishing the data desired.

Outstanding city, county, and Chamber of Commerce articles and pamphlets furnish additional publicity, and require the supplying of special material, photographs and cuts.

All of the foregoing releases and requests for material make it imperative to maintain complete records of these releases in addition to full coverage on clippings. These are filed under proper heads for ready reference. Thousands of photographs and halftone prints are indexed and placed in books to facilitate selection. Incidentally, this system has prevented duplication, and loss of material. The negatives and halftones are also properly indexed and filed.

A number of booklets and pamphlets have been prepared for general and special distribution. The most attractive of these is the 36-page artistically covered booklet "The Story of Water." This is used as a reference book in all East Bay area schools as it gives the history of the area's water supply and a complete description of the present system involving source, transmission, treatment, and distribution of the water supply.

The science classes of the schools and others find need for such information as is contained in the booklet "Protection of the Water Supply." This 14-page pamphlet explains what constitutes good water, how the supply is made safe, and makes clear by diagrams and description the operation of a modern filtration plant.

These two publications, which are used as text books on the local water supply, coupled with the showing of the film, "The Story of Water," in all the schools, give every child in the East Bay area complete information about the source, transmission and protection of the water supplied East Bay homes.

The pamphlet "Water, Where it Comes From, How it Reaches Your Faucet" is designed for general distribution. A large portion of this 8-page pamphlet is devoted to birdseye or perspective maps of the storage, transmission, and distribution systems. These are coupled with cuts and brief descriptions of the various features of the system. To give the financial picture of the organization, the pamphlet "Water and Tax Rate Reduction" was prepared. These booklets and pamphlets have been well illustrated and edited.

Messages are carried to the consumers by the medium of bill inserts designed to give exact information on the operation of the District. The majority of these are attractively lettered, properly illustrated, and the written material short and to the point. The present series deals with the source, storage, distribution, and filtration of the water supply.

Public Relations Audit

The public relations audit referred to from time to time in the article relates to the personal interview each year of many consumers taken at random throughout the area served. These consumers are for the most part approached on the assumption that recent pipe work might have disturbed their service. Other methods are used according to circumstances. The results of each interview are recorded on special forms headed "Personal Interview" in which the main facts are recorded by checking principal items and other remarks are written in when important. The value of the data gathered depends largely on the approach of the employee handling the interview. Our experience has shown that if worthwhile results are to be obtained from an audit of this character, it is desirable to use the conversational method of inquiry rather than the question and answer type.

The District's public relations program has been outlined and from it the reader has, perhaps, gleaned these facts; that the staff has a part in developing the program; that every effort is being made to make it practical; that planned record keeping is given an important place in the arrangements and, as a consequence, little is left to chance; that public relations problems cannot be solved overnight; that the theme of the program is "seeing is believing"; and that it is recognized that there is room for improvement.

We are aware that literally speaking a utility is only as good as the public believes it to be and as a result a tragic thing can happen if our public relations are not sound. No organization, therefore, can afford to assume an attitude of smug satisfaction over its program if it expects to be alert to changing conditions.

In any program, it is not a question of impressing people for the moment but it is long range goodwill that must be developed. We have found that a flexible and open-minded policy, which goes back to the original thought behind all this, that "public relations are human relations," is a wise policy to adopt.

A Motorized Apparatus for the Rapid Determination of Calcium and Magnesium in Water

By Wilfred F. Langelier

THE Clark soap test for water hardness is one of the oldest and best known tests used in analytical chemistry. Notwithstanding certain well-known inaccuracies, the simplicity of the test (using as it does a single reagent) and the general importance of the information which it furnishes are no doubt responsible for the fact that after nearly 100 years (1) it is still used daily, essentially in its original form, in literally hundreds of laboratories. Numerous investigators have studied the method for the purpose of eliminating some of its inaccuracies, mostly without success; and in recent years there has been a tendency to replace it by the Blacher method (2). This method utilizes a standard soap solution as titrating agent, but the sudsing properties of the soap are not utilized. It certainly requires greater skill and it is subject to essentially the same errors as are inherent in the Clark test. Recently Sheen and Noll (3), and also Daugherty (3), have discussed the newest modifications and the relative merits of the two methods.

In 1937, Brown and Villarruz (4) reported on a comprehensive study of the Clark method and showed that with the application of certain correction factors the method could be used to predict relative amounts of calcium and magnesium hardness. The writer was impressed by the work of these authors, but after a few trials concluded that if the method were to become of general use it would be necessary to eliminate those elements which were subject to the personal equation. It seemed likely that a suitable mechanical device which would provide uniform or reproducible conditions of aeration and soap addition would at least increase the precision of the original method. Within a few weeks such a device was con-

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A record of research contributed by Wilfred F. Langelier, Professor of Sanitary Engineering, University of California, Berkeley, Calif.

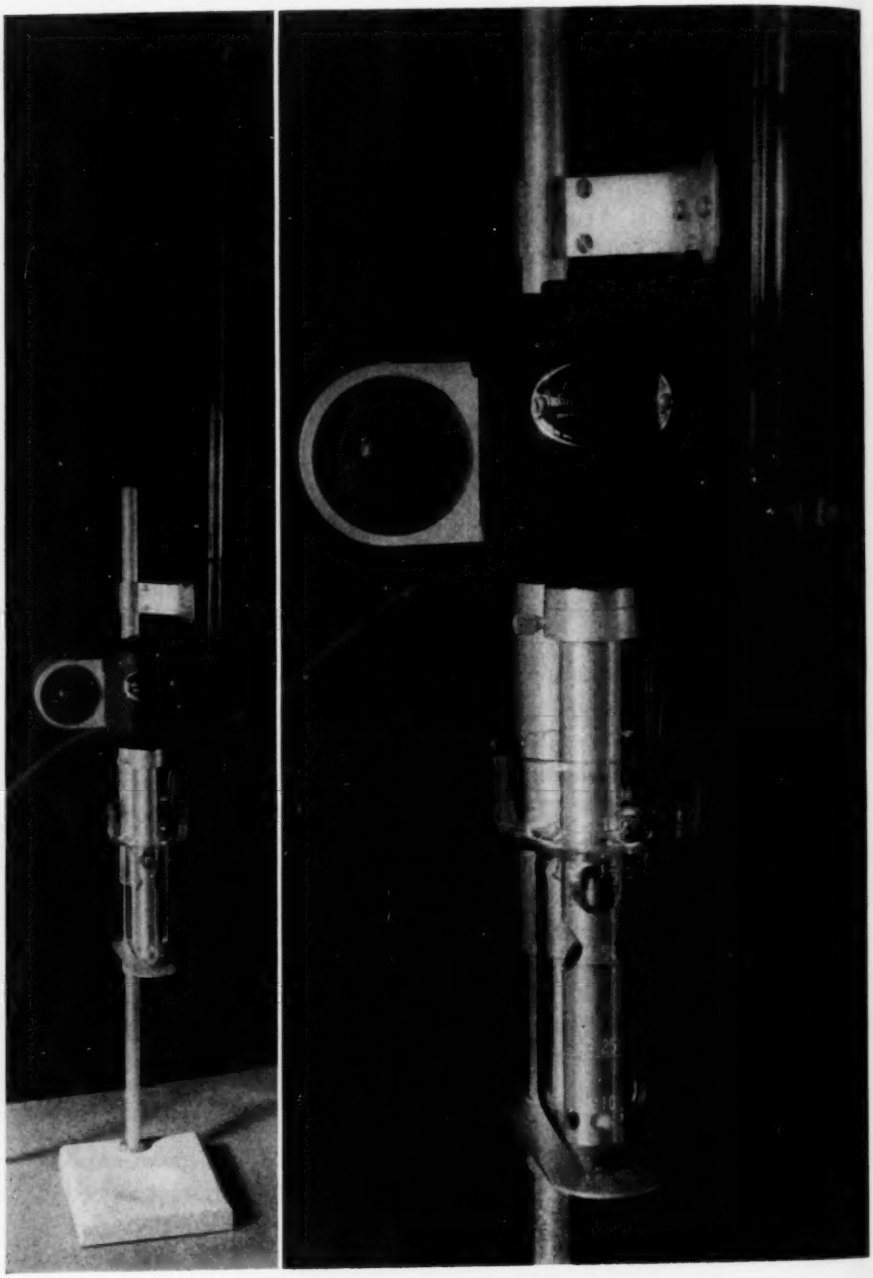

FIG. 1. Views of the Apparatus

structed, and the results obtained were sufficiently encouraging to warrant further work in this direction.

The apparatus in its present form is shown in Fig. 1. It comprises essentially a motor-driven aerating and recirculating device with an impeller in a vertical tubular casing. The speed of the impeller is regulated by a rheostat and is maintained at a degree sufficient to entrain air by vortex action. The entrained air which is discharged at the base of the impeller casing is not free to escape, but by centrifugal force is drawn back into the casing after it has spiraled upward to the elevation of two inlet openings located in either side of the casing above the impeller. Provision is made for the continuous addition of standard soap solution during constant aeration and mixing of the sample. The glass tubular cup which holds the sample has a cone-shaped bottom and a flared top, the purpose of which is to display the suds for confirmation of stability after the presumptive end-point has been indicated by an optical method. The optical method by which the end-point is indicated consists of viewing a light path through the sample at an elevation above the aerating space. The addition of soap beyond the amount necessary to combine with the hardness cations rapidly lowers surface tension to a degree sufficient to "emulsify" the air. That is to say, the air bubbles are reduced to microscopic dimensions and, being no longer subject to the acting centrifugal force, distribute themselves evenly throughout the sample. The tiny bubbles are in such concentration that the emulsion assumes a milky appearance and causes complete obstruction of the passage of light through the sample. The point at which this occurs corresponds to the true end-point as obtained in the hand method.

The ease, speed, and greater precision of the results obtained have permitted a critical study of the soap test itself as well as the development of new techniques for the determinations of calcium and magnesium in water, either separately or combined. It is with these studies that this paper is chiefly concerned.

Buffer Reagent

In addition to calcium and magnesium ions, water may contain other metal ions, as for example, hydrogen ions, which form insoluble soaps and which will accordingly be included in the hardness as determined by the soap test. In order to reduce these constituents to a minimum, it is common practice first to alkalinize the sample

with caustic soda, using phenolphthalin as an indicator. In the method herein described this step is simplified by merely adding to the sample one ml. of buffer reagent. This reagent is a saturated solution of borax in distilled water, which automatically adjusts the pH of the sample at 9.2. This pH is sufficiently high to insure the absence of hydrogen ions from free carbonic acid and yet is not too high to cause the precipitation of calcium carbonate (5), which, of course, would give low results. It happens also that this is the pH at which soap suds begin to form in distilled water. If it is desired, a suitable indicator, as for example, meta-cresol-purple, can be added to this reagent so that when the reagent is added to the test sample, its color will indicate excessive hydrogen ions, should they be present.

The amounts of soluble iron and aluminium cations ordinarily present in water are small and, under the conditions of the test, are precipitated by the buffer reagent, reducing the possibility of error from this source. Silica in water is probably present as undissociated silicic acid and has been found not to interfere.

Standard Soap Solution and Effective Titration Range

A good soap solution for this test would be one which not only will react quantitatively with calcium and magnesium but also will give a sharp end-point over a wide range of hardness. In addition, the solution itself should remain clear and stable, or free from hydrolysis under varying conditions of temperature.

It was found that the difficulty in attaining all of these necessary qualities was caused by the solvent used in the preparation of the solution. Alcohol, or similar solvent necessary for the preparation of clear non-hydrolizable solutions of soap for titrating purposes, unfortunately exerts a solvent action on the precipitated soaps of calcium and magnesium, thus limiting the range over which the test is practicable. Not only is the range limited, but also, because magnesium soap is more soluble than calcium soap, a second difficulty is introduced when a mixture of the two is titrated as in total hardness. This difficulty can be overcome by the use of a more concentrated soap solution. Whereas the commonly recommended or *Standard Methods* strength is approximately 0.02 normal, we have obtained decidedly better results with one which is approximately 0.06 normal. This stronger solution extends the useful titrating range nearly threefold and thereby reduces to a minimum the number of trial tests that must be rejected because of need for dilu-

tion of the sample. The end-points are much sharper in that when suds are formed they are much more likely to be permanent. An even stronger solution can be used to advantage in testing hard waters, but for general routine work the 0.06 normal strength was found to be quite satisfactory.

Castile soap has been most commonly used for this test. Since this soap is made from olive oil of varying grades, it is really an indefinite mixture of several "pure" soaps. With the view of attaining exact reproducibility, a study was made of the merits of various pure soaps. Those made from pure palmitic and stearic acids were eliminated after a few trials in favor of potassium oleate prepared by the saponification of oleic acid with potassium hydroxide in isopropyl alcohol. This soap is easily prepared,* is very soluble, and is particularly suited for use in cold water.

It is of interest to note here that it has been found practicable to use as a titrating medium an alcoholic solution of unsaponified oleic acid, provided borax or some other alkali is used as a buffer reagent. In this case saponification occurs while the test is in progress. The results are at least as good as with the potassium soap, and there is an advantage in that the acid soap dissolves in all proportions in alcohol. However, its use has been found to require a higher concentration of buffer reagent. Further studies are now in progress.

Standardization and the Lather Factor

The usual method of standardization is to make, first, a titration against a calcium solution of definite strength, and second, a titration against a distilled-water blank to determine the "lather factor." These two values plotted on coordinate paper locate a straight line, which is taken to be the standardization curve.

It is agreed that the standardization curve is theoretically linear; but the accuracy of fixing the slope of the line by the use of a "lather factor," which is defined as the distilled-water blank, is open to question. It is especially difficult to obtain consistent results when titrating a blank, even by use of a buffer reagent. Slight variations in the vigorousness of shaking and in the rate of soap addition often result in very wide discrepancies. Also, from a theoretical aspect it can be shown that the true lather factor is not the distilled-water

* Dissolve 30 ml. of U.S.P. oleic acid in 500 ml. alcohol (methyl, ethyl, or isopropyl). Add this to a solution prepared by dissolving 6 gms. of potassium hydroxide in 100 ml. of distilled water. Dilute with alcohol to one liter.

blank but a larger value which is made up of one or more additional parts, depending on whether calcium ions alone are present or whether both calcium and magnesium ions are present.

If distilled water is titrated, a permanent suds will form when under the condition of the test, soap has been added in sufficient quantity to emulsify the air. In the case of a calcium solution, an additional quantity of soap is necessary to start the precipitation of calcium. If a mixed solution of calcium and magnesium ions is used, another addition corresponding to that necessary to start the precipitation of magnesium is necessary before suds will start to form. Thus, in the titration of water in which both calcium and magnesium ions

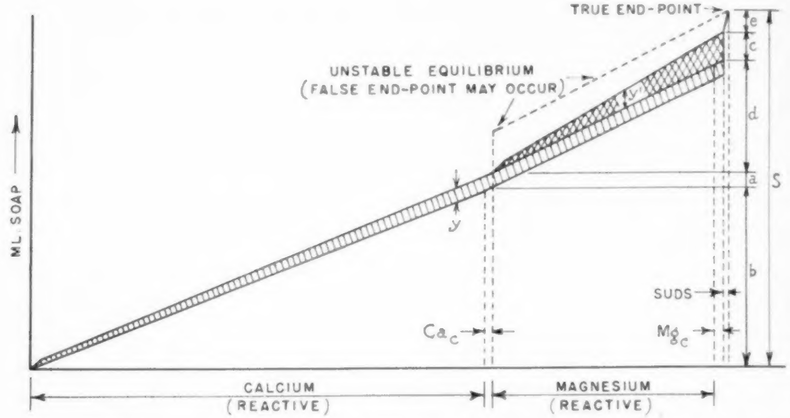

FIG. 2. Diagram showing the mechanism of the soap reaction in the progress of a typical titration of water containing calcium and magnesium ions.

are present, the true lather factor is equal to the sum of these three parts. A true lather factor which can be used in testing for total hardness must therefore be obtained by plotting at least two significant points and obtaining the intercept at zero concentration by extrapolation.

Figure 2 illustrates the probable progress of soap consumption during the titration of a typical water containing both calcium and magnesium ions. It will be noted that only the intercepts b and d increase with the hardness of the sample. The intercepts a and c represent the consumption of non-reactive soap required to maintain equilibrium in accordance with the law of mass action. The quantity of soap represented by these two intercepts is not even avail-

able to produce suds, since for this purpose the soap molecules must be retained in the air-liquid boundary surfaces. The quantity of soap which enters the interfacial boundary, thus lowering the surface tension and causing the suds to form, is represented by the intercept e. Therefore e is equal to the distilled-water blank. The correctness of this reasoning is supported by theory as well as by all of the experimental evidence obtained in this investigation.

The actual standardization curves of Fig. 4 demonstrate the extensive errors which result from the *Standard Methods'* procedure of using the distilled water blank as the lather factor. Curve B represents the actual standardization of a soap solution against standard

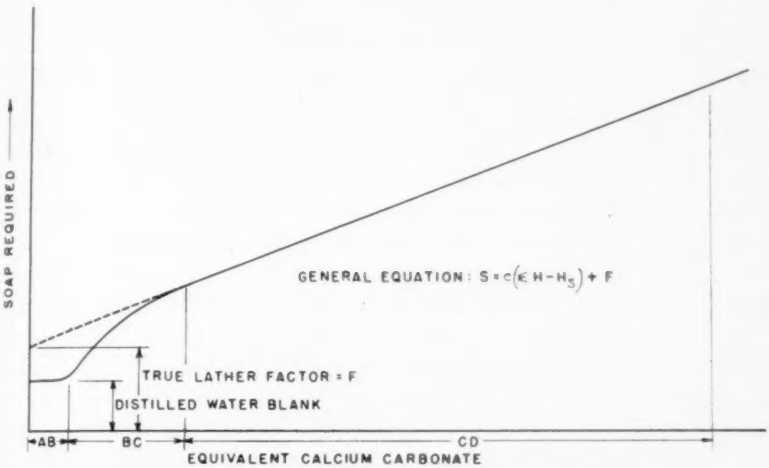

FIG. 3. A graph of the theoretical soap standardization curve

calcium chloride, in which the true lather factor is obtained by extrapolation to zero calcium concentration. Curve C represents the actual standardization of the same soap solution against the same calcium chloride standard, but following instead the standard procedure of using the distilled-water blank and one other point (in this case 12 mg. equiv. $CaCO_3$) for establishing the slope. For example, from curve B it is found that 2.0 ml. of the soap solution indicates 4.8 mg., whereas from curve C, the same quantity of soap indicates 5.2 mg. Thus, at this level, the standard procedure is found to give results which are 8 per cent too high. This is an appreciable error. If, however, curve C were standardized against a 4.0-mg. sample of

equivalent calcium carbonate as permitted in the standard procedure (which, incidentally, is within the range of greatest accuracy for the strength of soap solution recommended), it would coincide with curve *B* at the 1.8-ml. level, and in this range the calculated error would be smaller. However, in the higher range of titration, an even greater error would occur. Thus at the 4.0-ml. level the error would be 13 per cent. It seems that this difficulty can be overcome only by establishing the slope of the curve from two points, neither one of which is a blank. If this is done—using for the several tests, say 5.0 and 12.0 mg. equiv. $CaCO_3$—it will be found that the linear curve extended to zero hardness will give an intercept which is the true lather factor.

Standardization and the False End-Point

These investigations have shown that the troublesome so-called "false end-point," which has been often discussed in the literature of this test, can be controlled by the vigorousness of agitation, and a theory has been propounded to account for this peculiar behavior.

This theory conforms perfectly with wholly accepted principles of emulsification phenomena, in which the excellent emulsifying properties of soap are believed to be due to the fact that soap molecules show a strong tendency to go into the interfacial boundary surfaces rather than to disperse. Therefore, when in the soap test the shaking is vigorous, the interfacial air-water boundaries are increased and more soap is withdrawn into the boundaries where it is unable to combine with the magnesium ions in this part of the titration. If now the interfacial area is decreased by reducing the vigorousness of agitation, fewer and larger bubbles are produced, the soap molecules are forced back into the liquid, combination with magnesium ions occurs, the emulsion "breaks," and the suds disappear. However, it should be noted that if the shaking is too gentle, suds will not form even though the quantity of soap added exceeds that which is necessary to complete the reaction. Thus there is a likelihood of missing the true end-point altogether. For this reason, the vigorousness of shaking is an important factor in reducing to a minimum the difficulties and uncertainties of the false end-point. It is believed that "the vigorousness of shaking" is best controlled by some form of mechanical aeration in which the number and size of bubbles present are reproducible.

Theoretical Equation for the Standardization Curve

In Fig. 2, the ordinate y' represents the quantity of soap added to induce precipitation of magnesium. This ordinate gradually increases, in accordance with the mass law, until it reaches the value c, at which point the concentration of soluble soap reaches a critical value. The further addition of soap results in the formation of suds rather than in continued precipitation of magnesium. At this point, the concentration of magnesium will have reached a minimum value, designated as Mg_c, which will be the same regardless of the amount of magnesium originally present, provided this was appreciable (greater than about 2.5 mg.). The same condition holds for calcium, except that Ca_c is less than Mg_c.

This deduction makes possible the formulation of the theoretical standardization curve which expresses the quantity of soap solution required for any given hardness. This curve is shown in Fig. 3.

Since the amount of soap added is directly proportional to the amount of hardness cation precipitated, the general equation for this curve is

$$S = cH_p + F = c\,(\Sigma\, H - H_s) + F$$

Where

S = total soap consumed for the titration

c = proportionality factor

ΣH = total hardness originally present

H_s = that portion of ΣH which remains in solution at formation of suds = $Ca_s + Mg_s$

H_p = that portion of ΣH which is precipitated as insoluble soap = $Ca_p + Mg_p$

F = true lather factor = $(a + c + e)$

In the range of hardness CD, the quantity H_s will be constant and equal to the H_c value described above, so that this portion of the curve is linear. In the range BC (about 0.5 to 2.5 mg.) a phenomenon which might be called a "permanent false end-point" occurs; that is, because there is very little precipitated soap present in the mixture to catalyze the normal precipitation process, the amount of hardness cation remaining in solution at formation of suds, H_s, will be greater than the H_c value. The value of H_s for this range gradually increases as the hardness decreases; and from experimental evidence, it appears to vary from a magnitude of H_c at about 2.5 mg. to about $2H_c$ at zero concentration. This accounts for the gradual change in slope in

the *BC* range. If at the beginning of the titration the concentration of hardness cation is less than the H_s value for that concentration, no precipitation will occur and, as indicated by the horizontal segment of the curve *AB*, suds will form as in a blank.

Actual Standardization Curves

In Fig. 4, curve *A* represents an actual standardization of an approximately 0.06 normal solution of potassium oleate against a

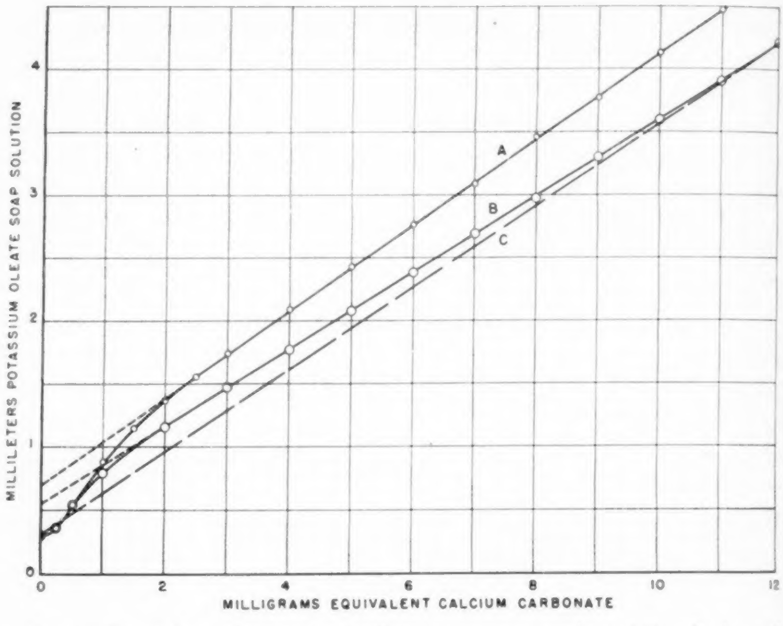

FIG. 4. Potassium oleate standardization curves against (*A*) solution of magnesium sulfate, (*B*) calcium chloride, (*C*) calcium chloride in accordance with *Standard Methods* procedure.

standard solution of magnesium sulfate. Curve *B* represents the standardization of the same soap solution against standard calcium chloride. It will be noted that these curves are not linear throughout their entire lengths but fall off at the lower concentrations as predicted in theory. Also, it will be noted that curve *A* gives results for magnesium which are nearly 20 per cent lower than for calcium. It is believed that this is due to the known fact that in water-alcohol mixtures magnesium soap is considerably more soluble than calcium

soap and that therefore a higher concentration of soap anions is necessary for its precipitation.

In the practice of testing waters these deviations are not of great significance, because in natural waters containing both ions it will be found that for the normal ratio of about one equivalent of magnesium to two equivalents of calcium, the correct results fall very close to the calcium curve; in fact, our results indicate that for this ratio the two curves are identical (see Fig. 5, curve

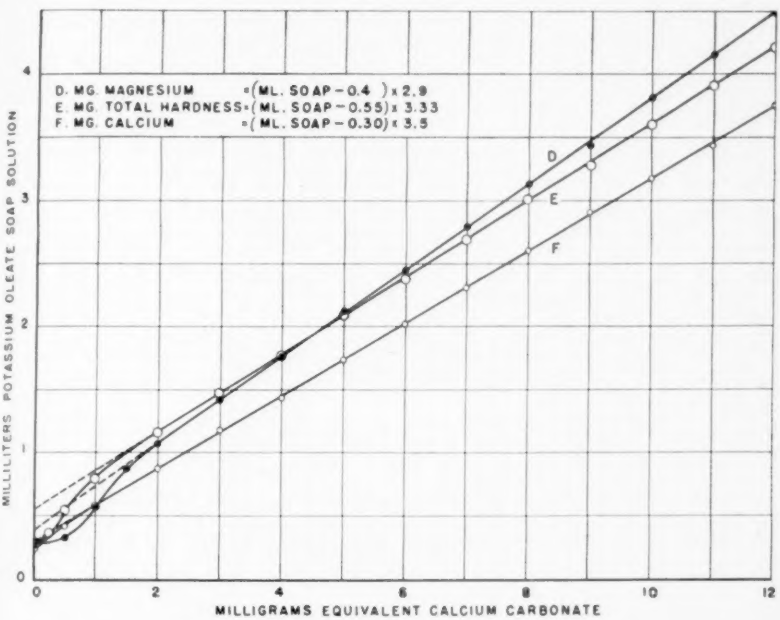

FIG. 5. Potassium oleate standardization curves for use in the determination of (*D*) magnesium (*E*) total hardness, (*F*) calcium in accordance with procedures described in text.

E). This is difficult to explain except by assuming that for this ratio of Mg to Ca the greater soap requirement of Mg is exactly compensated by the failure of the magnesium soap to precipitate completely. If the ratio is greater than stated, the results obtained for total hardness are likely to be low. Such errors can be detected by testing for each ion separately as described later and combining the test results. Also, in respect to the falling off of the curves at the lower values, this effect is not pronounced in the curve for the mixed

standard. Only in the case of very soft waters, as for example in zeolite-softened waters, will the error be appreciable if the linear equation is used in computing results; and even here, this error which gives low results can be materially reduced by taking the values directly from the curve.

In Fig. 5, three additional standardization curves are given. These are the actual working curves for the same soap solution used in obtaining the curves in Fig. 4 but standardized for the direct determination of calcium, magnesium, and total hardness. All three curves were standardized against a mixed solution of calcium chloride, magnesium sulfate and sodium bicarbonate. Curve *D* is for use in the determination of magnesium and was obtained by treating the standard with sodium oxalate for the precipitation of calcium and titration in the presence of buffer reagent. Curve *F* is for use in the determination of calcium and was obtained by first treating the standard to remove all carbonates and carbon dioxide and precipitating the magnesium as the hydroxide. The exact procedures for these determinations are included elsewhere in this paper. Curve *E* (which happens to be identical to curve *B* in Fig. 4) is for use in the determination of total hardness and was obtained by titrating the untreated standard in the presence of buffer reagent.

With each curve is given its mathematical equation by which milliliters of soap required are converted into milligrams of the constituent sought. In these equations, the number within the parentheses is the true lather factor for the particular curve and the number outside is the proportionality factor obtained from the slope of the curve.

Procedures for Direct Determination of Calcium and Magnesium

The ease and rapidity with which total hardness determinations could be made with the mechanical apparatus suggested the possibility of using it for the separate determinations of calcium and magnesium. It was believed, moreover, that if they could be made, such separate determinations would eliminate the principal error in the soap test, namely, the error due to the unequal soap consumption for equivalent amounts of calcium and magnesium ions. These experiments were completely successful, and it is believed that the procedures which have been developed can be readily adapted to the hand-shaking method.

Calcium. In the direct determination of calcium, there are two procedures: (1) The sample is first neutralized to methyl-orange with a strong acid, boiled to remove free carbon dioxide, and allowed to cool to room temperature. If at this point 2 ml. of 0.5 normal carbonate-free sodium hydroxide is added, the magnesium will be quantitatively precipitated and the calcium will remain in solution. If this solution has been previously standardized by means of the same technique against a standard solution containing both ions, the results obtained will be fully as accurate as if magnesium had been absent, and they will compare favorably with those obtained by the usual gravimetric technique. (2) Same as (1) except that carbon dioxide is removed without heating, by aeration in the mechanical apparatus. The aeration should be conducted for a period of not less than three minutes, or longer for low concentrations. The aeration will be more rapid if the sample is 50-ml. or less. After the sodium hydroxide reagent is added, it is advisable to agitate the sample at low speed for a period of one minute.

Magnesium. In the direct determination of magnesium there are also two procedures: (1) Same as that described under (1) for calcium, except that after boiling to expel carbon dioxide, one ml. each of saturated sodium oxalate and buffer reagent is added to precipitate the calcium and the boiling is continued for several minutes. The sample must be cooled before titration. (2) A preferred procedure is to treat the sample with one ml. of saturated sodium oxalate; after mixing, allow the sample to stand over night in order to complete the precipitation. One ml. of buffer reagent is added, and titration is completed as described for calcium.

Other interesting applications in soap titrimetry are possible, as for example, a method of evaluating the softening capacities of various soaps and soap powders. This study is now in progress.

Probable Errors

In preparing the standardization curves, it was found that the value of the quantity of soap used for a given titration could be duplicated with a standard deviation of not more than 0.05 ml. (corresponding to 0.15 mg. equivalent calcium carbonate) and usually of about half this amount. Thus any single titration value will have a probable error of not more than 0.10 ml. (0.30 mg.) if the true value is assumed to be a mean of several titrations.

In the testing of actual waters, the probable errors are of course

greater. The working equations are linear and thus do not always correspond to the true standardization curves, which fall below the linear values in the hardness range below about 2.5 mg. In addition, there is the possible error which might result from the many constituents present in natural waters which are not present in the solutions used for standardization.

In Table 1 are given corresponding values obtained by both soap titrimetry and gravimetric analysis for ten unknown samples. The average and maximum percentage deviations from the gravimetric values are as follows:

TABLE 1

Comparative Results of Calcium, Magnesium, and Total Hardness Determinations in Actual Waters by Soap Titrimetry and by Gravimetric Analysis; Results Expressed in p.p.m. Equivalent $CaCO_3$

SAMPLE	SOAP METHOD			GRAVIMETRIC ANALYSIS		
	Calcium	Magnesium	Total Hardness	Calcium	Magnesium	Total Hardness (Computed)
1	34	25	64	38.5	24.1	62.6
2	81	54	130	85.0	52.4	137.4
3	47	29	73	48.0	29.3	77.3
4	69	54	122	65.5	53.9	119.4
5	82	45	119	81.3	44.0	125.3
6	67	37	96	66.5	38.4	104.9
7	76	50	120	74.8	52.7	127.5
8	53	33	87	55.0	32.2	87.2
9	125	82	228	133.8	84.5	218.3
10	42	26	70	43.8	26.3	70.1

Percentage Deviation

	Maximum	Average
Total hardness	8.5	3.7
Calcium	12.0	4.2
Magnesium	5.1	2.6

In the soap titrimetry method as described herein, an independent check may be made by comparing the total hardness value as obtained directly with that computed from the separate calcium and magnesium determinations.

The author wishes to acknowledge the invaluable assistance of Harvey F. Ludwig in conducting much of the analytical work, in

the preparation of drawings, and in offering suggestive criticism. The gravimetrically analyzed water samples were supplied by the San Francisco Water Department.

Summary

A mechanical apparatus comprising a motor-driven aerator suitable for the determination of hardness in water is described. This apparatus permits the continuous addition of soap to an end-point indicated by the light-obstructing properties of emulsified air in water. A critical study of soap titrimetry, disclosing apparently unsuspected errors in former techniques, has been made. The progress of a typical titration of a water containing calcium and magnesium ions in which a false end-point occurs has been discussed in terms of the mass law and of the theory of emulsification. New techniques for the direct determination of calcium and magnesium in water, either separately or combined, have been described.

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Hazards to Employees in Water Works Plants

By A. A. Soldner

USUALLY when any group is addressed on matters of safety, there is much which can be said in derogation of their attitude towards safety, their safety organization and their accident record. There seems to be an exception, however, as regards water works plants, for judging by the record, which discloses for the period from January 1, 1937 to September 30, 1939, sixty-five injury cases incurred by employees of water works departments in twenty-three cities, they seem to have the earmarks of a rather safe place of employment. Just why the operation of water works should present such a good record cannot definitely be stated although several reasons might be advanced. First, certain prolific accident producers such as the circular saw of the woodworking industry, the power press of the metal trades, and the nip hazards of the paper mill, are not found in water works—in other words, water works employees are not exposed to as many of the more hazardous mechanical accident exposures. Second, water works do not operate on the same production basis as do most manufacturing plants where frequent set-ups and changes in operation are required. Chairs are not made today and tables tomorrow or an aluminum pan this morning and a metal stamping for an automobile this afternoon—but on the contrary the water works problem is the same day after day, which gives superintendents the opportunity to make specialists of all employees, thoroughly training them in every phase of their daily duties. Third, there is comparatively no labor turnover in water works and because of that fact, safety-trained men can be retained for many years instead of continually breaking in new men.

The subject assigned suggests that there are certain hazards in

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water works plants which have been subjugated into a safe state of being by reason of safety-conscious companies, organizations, managements and employees. But, nevertheless, certain hazards do lurk about ready to strike and attack the very second that an employee throws caution to the winds. Often, when an employee becomes fully trained and follows the same routine for a long time, he becomes a robot and ceases to exist as a careful, cautious, intelligent, thinking worker. That is the opportune time for an accident to strike—the time when it becomes so urgent for managers and supervisors to inoculate such workers with injections of a stronger serum of care, caution and safety. Let us now consider some of these hazards which may become transposed into accidents the moment safety promotion lags.

First, there are the chlorine hazards, present in practically every water works plant.[1] As the reader knows, chlorine is a greenish colored gas, is not explosive or inflammable but has a suffocating and stifling odor and is very poisonous. It is readily detectable before it is present in a dangerous concentration, yet in the least concentration detectable by odor (four parts per million parts of air) it may prove dangerous to those exposed to it for a period of one-half hour due to its irritating action upon the lung tissues. Because of the poisonous qualities of this gas, it is of the utmost importance that extreme caution be exercised in the handling thereof, as follows:

(1) Never permit a cylinder to drop or be violently struck.

(2) Never store cylinders where heavy objects may fall upon them.

(3) Never use a sling to handle cylinders but instead, use a cage or basket in which they are secured.

(4) Never store cylinders where direct rays of the sun[2] fall upon

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[1] Reference should be made to three valuable reports made by the A. W. W. A. Committee on "Chemical Hazards in Water Works Plants." These are: "First Report of Committee on Chemical Hazards in Water Works Plants—Chlorine," Jour. A. W. W. A., **27:** 1225 (1935); "Second Report of Committee on Chemical Hazards in Water Works Plants—Ammonia," Jour. A. W. W. A., **28:** 1772 (1936); and "Third Report of Committee on Chemical Hazards in Water Works Plants—Sulfur Dioxide and Caustic Soda," Jour. A. W. W. A. **31:** 489 (1939).

Reference to safe handling of chlorine can also be found in *Safe Practices Pamphlet #71* of the National Safety Council. The manufacturers of chlorine are also in a position to give good advice upon the subject.

[2] While it may be useful, from the viewpoint of the safety engineer, to avoid storing chlorine cylinders where the sun's rays may fall upon them, it cannot be considered imperative that they not be so stored. Conditions

them, or where temperatures exceed 125° F. as the fusible plug melts at about 170° F. and softens at a lower temperature.

(5) Never store cylinders near waste, oil, gasoline or live steam.

(6) Always store cylinders in upright position and secured against falling.

(7) Never force connections that do not fit.

(8) Never tamper with the safety devices in the valves or cylinders.

(9) Use only such valves and gages as are designed for chlorine.

(10) Always open valves slowly using the wrench provided by the manufacturer.

If chlorine gas escapes from a leak, the rules to observe are briefly:

(1) Avoid panic.

(2) Refrain from coughing.

(3) Keep mouth closed; breathe through nose.

(4) Do not take deep breaths.

(5) Work carefully toward gas mask.

(6) Put on mask and adjust carefully.

The mask having been donned the next job is to stop the escape of gas. If it cannot be done otherwise, it sometimes can be stopped by turning water onto the leaking cylinder, the escaping chlorine frequently cooling the water sufficiently to freeze the leak shut. As soon as the leak is temporarily closed, the gas should be disposed of by running the chlorine into suitable containers or by absorbing it in a solution of lime, caustic soda or soda ash. If this cannot be done and the leak cannot be stopped, the cylinders may be removed to an insolated spot and the gas released but, before releasing, all persons not equipped with proper masks should be kept at a considerable distance, on the windward side and on a higher elevation since chlorine gas is heavier than air and will flow to the lower levels.

Masks to be used as protection against chlorine gases should be such as are approved by the Industrial Commission. Employees should be fully instructed as to the proper use of such masks and frequent inspections should be made to see that no parts of such masks have deteriorated and that the seal at the bottom of the cannister has not been removed. These masks should be placed in such positions that they will always be available and in such place that

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during shipment of single tank cars and multiple tank cars result in exposure to the sun's rays. The temperature limits given by the author are important as are also the cautions against storage near steam pipes, radiators, etc.

access to them in time of need will never be cut off by escaping gas.

In case anyone should be overcome and affected by chlorine, the following steps[3] should be taken: first, a physician should be called; second, the person should be removed to the fresh air, away from the gas, and laid on his back with his head slightly elevated; third, the patient should be kept from coughing, if possible; fourth, he should be given $\frac{1}{2}$ teaspoonful of essence of peppermint in hot water or a moderate dose of Bromo Seltzer or a glass of milk or stimulant. If the patient is unconscious and not breathing, artificial respiration operations should be commenced at once.

Another hazard that may be encountered is ammonia, the fumes of which are repellant to the human system and cause coughing, sneezing, "running" of the eyes and gasping for breath. Deaths from this cause are rare because the pungent odor forces those exposed to retreat to a safe distance.[4] However, if the concentration exists in such amounts that immediate irritation of the throat and eyes is present, then ammonia, like chlorine, is dangerous in exposures of more than one-half hour. Ammonia will burn if sufficient external heat is applied but it is not ordinarily considered explosive except under high temperatures when it will break down into nitrogen and hydrogen, the latter being explosive. Leaking cylinders of ammonia may be handled in a manner similar to those of chlorine and it may be absorbed in an acid solution or even in plain water if a sufficient quantity is available. It is suggested that a safe means be provided for drawing off all the ammonia in the system and for disposing of it in a safe way. Also properly approved masks should be provided and used in such emergencies.

As to the ventilation required in chemical rooms or where chemical processes are encountered it may be briefly stated that protection to the health of employees therein may be accomplished: first,

[3] All safety measures should be subject to directions from a responsible physician in charge of department or company accident practice. This is important from a legal standpoint.

The directions given by the author do not coincide with those given by the A. W. W. A. Committee (Jour. A. W. W. A., **27**: 1235 (1935)). That report contains a digest of first aid practice and should be brought to the attention of the staff physician *before an accident occurs*. His stipulations as to emergency procedure should be followed.

[4] Emergency procedures to be followed if ammonia escapes are to be found in the report of the Association's Committee (Jour. A. W. W. A., **28**: 1772 (1936)).

by a general ventilation system to provide a continuous introduction of fresh tempered air; second, wherever it is practical all sources of contamination should be provided with proper hoods connected to an efficient exhaust system in accordance with the Industrial Commission's General Orders on Dusts, Fumes and Gases; and third, where it is impractical to exhaust injurious gases at their source, all persons exposed shall be provided with approved masks or respirators as has been mentioned heretofore.

Electrical Hazards

The electrical hazards involved in water works plants are quite similar to those encountered in the average electrical power plant. Usually, every attempt is made in these plants to conform to the State Electrical Code. However, a few of the everyday incidental hazards should be mentioned, such as: the necessity of protecting the front and rear of switchboards by means of proper insulating floor or mats, the enclosure of all live parts, the grounding of all equipment including portable tools and appliances, the use of proper hand or extension lamps and the use of weatherproof sockets and fittings in all damp or wet places. The peculiarity of electrical accidents is that they are usually very slight or very serious, too often of the latter classification, for of the seventy-one electrical accidents in Wisconsin in 1938 one out of every seven was fatal. The seriousness of electrical accidents is also shown by a glance at the statistical record of the Commission which discloses the average number of days lost per general accident to be 96.9 days as compared to 891.8 days for the average electrical accident.

As for mechanical safeguarding, all can be summed up in the statement that guards and enclosures are required about every piece of moving equipment or machine, such as flywheels, belts, pulleys, chains, sprockets, gears, shafting, clutches, collars, couplings, etc. As a general rule all revolving parts less than seven feet from the floor or working platform are considered "exposed to contact" and should be guarded, i.e., completely enclosed on all sides with openings no larger than one-half inch. There are certain exceptions, for instance, gears, which regardless of where located are required to be solidly enclosed on all sides. The General Orders on Safety today are very specific as to these requirements and it is suggested that these be consulted as a criterion for mechanical safeguarding.

Ladders are hazardous in all places of industry and no exception is

found in water works plants. In 1938 there were 434 ladder accidents settled under the compensation act with an average loss of 109 days per accident, many of these being the result of excessive side play, ladder slippage and breakage, and broken or cracked rungs or stringers. Too often when a ladder looks shaky out comes the old paint bucket and brush and the old wreck of what was once a ladder is literally soaked. But don't kid yourselves! The old saying "Save the surface and you save all" is untrue when ladders are concerned. The paint does not make the ladder any safer, it just improves the appearance and you know how deceiving looks may sometimes be! This is why the safety code forbids the painting of ladders with any opaque pigment. Before we pass from the ladder hazard, one of the provisions added in the Revised Orders on Safety requires that ladders on water towers be equipped with cage or basket guards which may cost as much as $300. Would anyone object to investing that much to save a life? Yes, there have been objectors—just a few months ago a life was lost in a fall from a tower leg on which there was no cage, because someone had a poor conception as to the value of life.

Hazards on Construction Projects

Several hazards are apt to be found during construction work. This may be due to the fact that scaffolding is outside the scope of the ordinary routine work of the water works plants. In many cases it might be said without fear of much contradiction that several orders of the Safety in Construction Code would be found violated, such as using improperly selected and too light material, exceeding the safe span of 8 ft. for ordinary work, lack of proper bracing to prevent lateral movement, lack of proper footings to prevent sagging, permitting walkway planks to project too far beyond supports, using improper and unsecured ladders, and allowing upturned nails to lie about.

Trenching operations are often carried on in such a way as to be extremely hazardous and in many cases completely ignoring the General Orders on Safety in Tunnel and Trench construction. In a recent case, a trench about 7 ft. deep was being dug in soil that was liable to split easily. Such trench required at least 2x6 in. planks for uprights spaced 3 ft. center to center and then properly cross-braced, but no timbering was provided—until a man was injured in the cave-in. In another case, a man was severely injured through

the pelvic regions in a trench about $6\frac{1}{2}$ ft. deep and again without any trace of timbering even though the soil was a clay and gravel mixture, all because someone was shirking his job and had no regard for the safety of his fellow being. In the investigation of the accident, the men were found working in another trench construction job but this time 15 ft. deep and with less than half the timbering required. Even the sending of one of their men to the hospital did not make them think. They had an accident but it taught them nothing. They had a safety code but they did not use it. They know the workings of the law of gravitation but they seem to think it had been repealed. Then too, there is also the all important task of guarding and barricading the tops of all excavations and to mark these locations by red lights at night.

Hazards from Hand Tools and Operations

How about the hand tools which your men use? Have the jaws of your wrenches become spread or badly worn? Are the handles in your sledges and mauls crudely and loosely fitted? Are they slivered or cracked? Are the men permitted to use mushroomed tools with needle-like particles of steel flying off at almost every blow? If so, there is chance for improvement, for out of the total number of 20,383 cases settled by the Industrial Commission, last year, 2,050 resulted from the use of hand tools, such as axes, knives, hammers, wrenches, shovels, saws, bars, sledges, chisels, etc., which were often defective in one way or another.

There is another hazard which is found in such operations as the breaking of stone or concrete, cutting of pipe, calking, grinding or buffiing, without proper protection for the eyes. Here we often encounter the ancient argument that goggles cannot be seen through —yet some would prefer to take a chance and gamble, only later in life trying in vain to see through a glass eye. Have you ever seen the driver of an automobile remove the windshield of his car because vision through it was obstructed by frost, or snow or rain? Goggles *too*, can be cleaned and made visible. Try it sometime. Goggles *can* be worn but because of their absence there were 725 eye accidents in Wisconsin last year of which some 525 disabilities occurred because of cuts, punctures, or lacerations of the eye, and infection because of such wounds—cases which proper goggles might have kept off the record. Forty-five or one out of every sixteen cases involved total loss of vision and 78 involved partial loss of vision or in other

words one of every six cases involved permanent loss of vision in some degree.

Hazards that should not be overlooked are encountered at manholes where are found various gases, some due to decomposition of organic material and some from other causes. Among those resulting from the former are: first, methane, or marsh gas, an inflammable gas formed when vegetable matter decomposes under water, and because it is heavier than air, a health hazard is also involved because of the deficiency of oxygen which may be encountered; second, hydrogen sulfide, a colorless, poisonous, inflammable gas which hangs to the bottom; third, phosphine gas, poisonous and also inflammable and possessing the unusual property of taking fire spontaneously upon coming into contact with the air, which might be sufficient to ignite any inflammable gas present; and fourth, carbon dioxide, a non-inflammable and non-poisonous gas but dangerous because in displacing the oxygen it may cause asphyxiation. Other explosive gases which may be encountered in sewers may be caused by the heavy gases from traveling automobiles and trucks, or by the gasoline or crankcase drainings from filling stations and auto repair shops which are discharged into sewers, or by illuminating gas escaping from leaks in underground mains and thence seeping into the sewers.

Precautions Against Sewer Gases

Because of the great variety of gases, poisonous or explosive or both, which may be encountered in sewers and sewer manholes, proper precautions must be taken: first, to protect the health of those who must enter these manholes and, second, to prevent explosions. As a matter of extreme safety, procedure along the following lines is recommended: First, our supposition must be that poisonous and explosive gases are present. Second, the atmosphere must be tested before anyone is permitted to enter. One foreman was accustomed to lower a lighted lantern to test for carbon dioxide and oxygen deficiency. If the light became extinguished he declared it unfit for the men to enter; on the other hand, if there was a sudden flare accompanied by a loud banging noise, he decided that explosive gases were present, i.e., if he were left alive to make the decision. (This guess work has now become obsolete with the introduction of reliable gas detectors.) Third, adequate ventilation must be provided before anyone is permitted to enter. Several manhole covers should be taken off in the vicinity of the operations.

It is also advisable to flush out the sewers with water. This would remove solid organic matter and thus prevent more gas from being formed and also has the additional advantage of setting the air in motion. Fourth, open flames and lights must be kept away and flashlights or proper waterproof portable extension lights, properly guarded and without switch should be provided and used. Fifth, persons entering manholes or sewers should be equipped with approved masks or respirators. It will be well at all times to proceed very cautiously and in all cases it is strongly urged that an explosimeter be employed to test for explosive mixtures and thereafter to require definitely that each man entering the manhole be equipped with an airline respirator supplying him with fresh air during the period of operations. To throw caution to the winds and to trust in luck may result in disaster such as occurred some years ago when a man entered a sewer manhole to receive a hose to be used for flushing operations. He soon became unconscious and a fellow employee went down to rescue him and he also collapsed. One after another made repeated attempts to rescue those who went before, until five men died and three others were overcome as a result of inhaling the gas that was present.

Costs of Water Works Accidents

Such are some of the accident hazards to be found in the operation of water works plants and which have apparently been well subdued. Before closing, let us glance briefly over the 65 accidents which were mentioned at the beginning, and which resulted in a medical and indemnity cost of $12,268.91 or an average cost of $188.75 per accident. These accidents as far as accidents are concerned, do not present an alarming picture: in fact, outside of the one fatality, it is a rather commendable record. But one thing is shown and that is that accidents can and do occur whenever there is a let up in the promotion of safety work. It illustrates what happens when an employee sometimes becomes too sure of himself and does things in a mechanized manner; it illustrates what may occur when management once trains employees but then forgets and forsakes them, and fails to check on the hazards of the various working conditions, the unsafe practices or the near accidents, and also forgets that man failure and not machines is the cause of most accidents, and that this man failure may not always be on the part of the employee, but may sometimes be charged against management.

Chief Causes of Accidents in Water Works

Of the 65 accidents, 23 can be attributed to handling or moving material and objects. Naturally, the easiest procedure is to put the blame upon the injured person, but does it all belong there? Is it not possible that some mechanical power might sometimes be used, or cannot more man power be supplied instead of permitting one man to tussle alone with an object that is too heavy or cannot the man be taught to lift properly so that the entire load is not upon the back alone but distributed to other muscles of the body? Eighteen of the 65 accidents were due to poor footing, slips and falls. Again, should we put all the blame on these injured men? Could we have done better under the same conditions? Is a man to be blamed because a co-worker left a wire in his path over which to stumble, or is it his fault that no decent ladder was provided for his climbing out of the sewer manhole? Ten of the 65 accidents were the result of hand tools. In one the hammer head separated from the handle causing an injury to a co-worker. Can the employee alone be blamed if he was not provided with proper tools?

In this manner we might go on painting the picture black but that is not the real purpose. There is a cause for everything, and usually the occurrence of an accident is the result of somebody somewhere doing something wrong. We cannot retract and remove the suffering occasioned to the injured person, but we can profit by experience to the end that such shall not occur again. As said before, 65 accidents during a period of 21 months is not a bad record, but it corroborates what was said before, that there must never be a let-up in the safety program. Whether such lapse will be permitted is entirely up to men in the water works plants. Whether there are accidents or not is entirely in the hands of water works men. Whether robots are permitted instead of cautious, thinking, safety-minded men, is for superintendents to determine. Superintendents must continually see the difference between safety and carelessness, the difference between the twenty-five cents a living man pays for a shave and the $5 that the dead man pays, the difference between a $30 wool coat the safe worker buys and the $300 wooden coat that the careless worker must pay for, the difference between the twenty-five cent taxi to the theater and the $25 trip to the cemetery. It is largely up to management whether men are permitted to wear a warm woolen coat or are put away in a cold wooden box. It is

management's problem and can be solved, not through arithmetic, algebra or trigonometry, not with mechanical or chemical engineering, but with the mere good common sense of safety, and a deep regard for one's fellow men; such as Abraham Lincoln had when he said: "It is the duty of every man to protect himself and those associated with him, from accidents which may result in injury or death."

Cathodic Protection on Domestic Distribution System at Treasure Island

By Charles H. Lee

TREASURE ISLAND has attained popular fame as the site of the Golden Gate International Exposition and the greatest man-made island in the world. Among water works engineers it may retain its fame as one of the hottest spots for steel pipe corrosion known to the profession. Within five months after completion, leakage was reported from the welded steel mains of the domestic water system. Investigation showed that the exterior surface of the pipe, where exposed by removal of the asphalt dip, was blotched and occasionally deeply pitted. Leaks were found where pits had penetrated to the inner surface of the pipe wall.

The magnitude of the corrosion problem facing the Exposition engineers can be visualized by stating that there were either in the ground or being laid, 40 miles of thin steel pipe composing seven independent systems, several of which it was found later were more or less in accidental contact at service connections. The pipe in these systems differed widely with respect to metallic cross-section and type of joints. Application of a remedy was further complicated by the intensive heavy construction activities going on in connection with building the Exposition. Not the least of these was an extensive landscaping and paving program in progress on the ground surface above the piping.

Investigation showed that the cause of the pitting was soil corrosion intensified by galvanic currents induced by extreme and localized differences of soil moisture and salt content in the dredger fill material in which the pipes were laid.

This paper describes the soil conditions which gave rise to such

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A paper presented on October 26, 1939, at the California Section Meeting at San Francisco, by Charles H. Lee, Consulting Engineer, San Francisco, California.

FIG. 1. Clay Balls Deposited from Dredger Pipe Lines at Treasure Island

FIG. 2. Layer Clay Deposited in Undrained Pools during Construction of Fill at Treasure Island

active corrosion, and the manner in which cathodic protection was applied in order to retard corrosion so that exposed piping would last for the duration of the Exposition. The paper is of especial interest because it describes an experience in applying cathodic protection to distribution systems that co-exist with other utility systems. It was stated two years ago at the Annual Meeting of the California Section that this would be "difficult, if not impracticable."[1] At Treasure Island the problem could be approached in a broad way because all systems were under the control of one organization. Furthermore, the results can be clearly appraised for the reason that the area is isolated and free from stray electric currents. The results are therefore of importance for they show what can be accomplished physically in controlling soil corrosion due to galvanic currents in an assembly of superimposed utility networks.

Soil Conditions

Treasure Island is a dredger fill upon the site of Yerba Buena Shoals in San Francisco Bay. It is rectangular in shape, 5,520 ft. long, 3,410 ft. wide, and 400 acres in extent. The fill has an average depth of 32 ft. and is retained and protected from erosion by a rock sea wall.

Material composing the fill was excavated from submerged borrow areas adjacent to the Island by means of hydraulic suction dredges, and transported in suspension through long pipe lines. During much of the construction period the fines were carried away by waste water, except as the latter was locally and temporarily ponded behind ridges of coarse material. The closure of the north sea wall, however, nearly four months before completion of the fill, trapped a large mass of soft mud in the north central portion. This was later partially removed and replaced by sand, but extensive isolated bodies of mud still remain in this area.

The fill as deposited is composed principally of layered sand with frequent admixture of broken shell and occasional piles or ridges of yellow and blue clay balls (Fig. 1). The texture of the sand is generally fine, with local areas of medium to coarse sand and fine gravel, the latter bordering the northern two-thirds of the eastern sea wall for a width of approximately 1,000 ft. Medium to coarse sand also borders the western sea wall. Immediately against the

[1] Knudsen, H. A. Cathodic Protection of the Mokelumne Aqueduct. Jour. A. W. W. A., **30**: 38 (1938).

sea wall is a zone of clay and silt representing material excavated by clam-shell dredge from the bottom of the adjacent bay as a backing for the sea wall. Throughout the fill there are also occasional small thin beds of relatively impermeable gray clay, irregular in extent, representing fines which settled out in isolated pools during dredger operations (Fig. 2).

The clay balls represent chunks of cohesive material which were rounded by passing through pipe lines but failed to disintegrate. They are of two types—very sticky fine-textured impermeable blue clay and semi-friable, semi-permeable yellow sandy clay. The former is derived from marine clay beds deposited from salt water

TABLE 1

Chemical Analysis of Sea Water

(Sample from Pacific Ocean near Cliff House, San Francisco)*

CONSTITUENT	PARTS PER MILLION
Sodium (Na)	11,275
Potassium (K)	
Calcium (Ca)	426
Magnesium (Mg)	1,212
Boron (B)	—
Sulfate (SO_4)	2,510
Chloride (Cl)	18,200
Carbonate (CO_3)	0
Bicarbonate (HCO_3)	159
Total	33,394

* Collected by Division of Water Resources, State of California, Aug. 7, 1929, (Bul. No. 27, Table 36).

upon the floor of the bay, and the latter from older fresh-water alluvium underlying the marine deposits. Within the top few feet of the fill, the clay balls have been widely distributed by grading operations and isolated clay balls are frequently found in bodies of pure sand.

Salinity

The fill when completed was saturated with sea water practically to the surface (elevation +13.0 ft.). The chemical constituents of sea water are shown in Table 1. This water imparted to the soil a chlorine content of over 5,000 p.p.m. of dry soil.

Subsequent drainage by pumping from well points and percolation

through the sea wall, followed by leaching with rainfall and artificial sprinkling, completely removed salt water from the sand but failed to leach the clay. Tests made during the installation of the domestic water system showed that leached blue clay balls contained from 800 to 2,500 p.p.m. of chlorine, leached yellow sandy clay balls 500 to 1,500 p.p.m., leached clay layers 1,000 to 2,000 p.p.m., and leached sand less than 100 p.p.m. Unleached blue clay balls contained as high as 5,000 p.p.m. of chlorine and unleached sand under clay layers from 850 to 3,500 p.p.m.

Characteristics of the various types of soil with respect to pipe corrosion are indicated by the results of laboratory tests (Table 2).

TABLE 2

*Corrosion Characteristics of Treasure Island Soils**

LOCATION OF	TYPE OF SOIL	WILLIAMS-CORFIELD CORROSION INDEX†	EQUIVALENT RESISTIVITY BY SHEPARD METER OHMS/CU.CM.
Aves. 5 and H	Blue marine clay	17.2	114
Aves. 5 and H	Sand	2.1	1840
Ave. 6 East of E	Yellow sandy clay	3.1	1115
Ave. 16 bet. L and K	Blue marine clay	9.1	267
Ave. 11 at 12th	Coarse sand	0.9	6050
Ave. 2 and G	Clay and sand	9.5	255
Ave. E and 4	Sand and salt water	10.1	242

* Tests by Bureau of Tests and Inspection, Pac. Gas & Elec. Co.

† Grams weight of metal lost by a 4-inch length of ¾-inch pipe nipple, 3 in. of which is buried in a can of soil to be tested and subjected to a battery current discharge for 24 hr. at a potential of 6 volts.

These tests show that all samples containing any degree of clay would be ordinarily classed as "bad," and especially so the blue marine clays. The sand samples on the other hand would be classed as "fair" to "good."

Summarizing, it may be stated that the soil in which steel pipe at Treasure Island was laid is exceedingly heterogeneous, with highly corrosive and electrically non-resistant moist salty clay balls in close proximity to bodies of relatively dry sand almost free from salt and highly resistant. This irregularly broken formation with great differences in soil moisture and salinity, gives rise to innumerable small galvanic circuits, which added to the highly corrosive character of the salt clay, produce unusually severe corrosion conditions for steel pipe.

Utility Distribution Systems

The corrosion problem at Treasure Island centers around the domestic water system. To control corrosion in this system, however, it is necessary to consider every metallic network on the Island,

TABLE 3

Length of Steel Pipe in Utility Systems at Treasure Island

SIZE OF PIPE	THICKNESS		HIGH PRESSURE	DOMESTIC WATER	GARDEN SPRINKLER	SANITARY FORCE MAIN	GAS SYSTEM	LAGOON & FOUNTAINS	SERVICE CONNECTIONS*	
									Water	Gas
inches	*gage no.*	*inches*	*feet*	*feet*	*feet*	*feet*	*feet*	*feet*	*feet*	*feet*
16 O.D.	10	.1406	12,639			2,051		360		
14 O.D.						734		210		
12 O.D.	12	.1093	13,639					1,160		
10 O.D.	12	.1093	14,300			2,692		931		
8 O.D.	14	.0781	7,618	15,721		4,522		1,398		
6 O.D.	14	.0781	3,300	15,223		1,440		441		
5 O.D.								1,536		
4 O.D.	16	.0625		755		130				
4 I.D.	Std.	.237		4,945	557		4,529 (b)	462	1,400	
3 I.D.	Std.	.216			1,992		1,108 (b)	256	1,000	
							953 (a)			
2½ I.D.	Std.	.203		1,886	1,721		1,103 (b)	35	1,300	
2 I.D.	Std.	.154			5,152		2,000 (b)	479	4,200	1,000
							12,566 (a)			
1½ I.D.	Std.	.145			7,582		2,300 (b)	602	1,100	800
1¼ I.D.	Std.	.140			1,664		450 (b)	258	400	1,400
1 I.D.	Std.	.133			19,152		440 (b)	12	2,300	2,400
¾ I.D.	Std.	.113			2,805			355	4,200	2,400
½ I.D.		.109							500	2,000
							11,960 (b)			
Totals in Feet			51,280	38,530	40,625	11,569	26,696	8,495	16,400	10,000
Miles of Pipe			9.7	7.3	7.7	2.2	5.1	1.6	3.1	1.9
Total Miles Pipe								33.6		38.6

High Pressure System: welded pipe asphalt dipped and wrapped with 23½ lb. rag felt.

Domestic Water System: welded pipe asphalt dipped.

Sanitary Force Main System: welded pipe asphalt dipped.

Garden Sprinkler Systems: standard threaded pipe; ¾ reconditioned asphalt dipped and ¼ bare pipe.

Gas System: (a) double wrapped pipe; (b) bare pipe.

Service Connections: bare pipe.

Lagoon and Fountain Systems: welded pipe asphalt dipped.

* Lengths estimated.

including both steel pipe installed by the Exposition Company for distribution of water and gas, and the lead-covered cables of the Pacific Telephone & Telegraph Company. This condition resulted from the many instances of physical connection or accidental contact which permitted flow of electric current from one system to another,

thus rendering it impossible to distribute uniformly the electric current introduced into the soil for cathodic protection of the domestic system. Not alone was it impossible to protect uniformly the domestic system if considered alone, but other systems which picked up current intended for the domestic system would experience active local corrosion where none existed before.

There are eight superimposed utility distribution networks to be considered. A brief descrption of each will be helpful as a background for understanding the various steps taken in applying cathodic protection. Following is a list of systems, and on Table 3 are assembled detailed data regarding lengths, sizes, wall thickness, and type of pipe: high pressure water system, domestic water system, garden sprinkling systems, sanitary force main, gas distribution system, fountain and lagoon circulating systems, drainage pumping systems and telephone system.

High Pressure Water System.

This consists of an interconnecting grid of 8- to 16-inch welded steel pressure main, 9 miles in length, serving 210 fire hydrants at a working pressure of 100 to 106 lb. per sq.in. The source of supply is a 3,000,000-gallon reservoir on Yerba Buena Island, with flow line elevation at 260 ft., fed by the San Francisco Water Department system via the San Francisco Bay Bridge Pumping Plant and 10-inch pipe line over the suspension spans of the bridge. The pipes, after pre-heating, were dipped in hot asphalt. They were also given a single wrapping of 30-pound asphalt impregnated rag felt. Pipes were laid under contract during the period August 20, 1937 to February 28, 1938. Emergency salt water supply for fire protection was pumped into the system immediately after completion. Fresh water was admitted to the system March 23, 1938 after thorough sterilization with liquid chlorine.

Domestic Water System.

This is an interconnecting grid of 4- to 8-inch welded steel pipe supplemented by $2\frac{1}{2}$- to 4-inch standard screw pipe. The mains have a total length of 7 miles. The system is operated at a pressure of 64 to 70-lb. per sq.in. Service connections of bare standard black steel screw-connected pipe 1 to 4 in. in diameter have an approximate length of 3 miles. The system is fed at four points through pressure regulators, the principal one drawing directly

from the reservoir main where it enters Treasure Island at the southwest corner. Other regulators draw from the high pressure system at three conveniently located points and are opened only during the daily period of maximum draft. The system supplies water to the exposition palaces, exhibitors' buildings, concessions, garden sprinkling systems, ornamental fountains, drinking fountains, and the lagoon. It has a covering of asphalt applied as a hot dip to preheated pipe. The original plans and specifications included also a wrapping similar to that used on the high pressure pipes. This was finally eliminated for reasons of economy, it being considered that the asphalt dip would provide sufficient protection for a period of 20 months including the duration of the Exposition. The system was installed under contract January 10 to April 20, 1938. Water was turned into the system immediately after completion.

Garden Sprinkling Systems.

There are 25 of these systems, consisting of standard black steel screw-connected pipe $\frac{3}{4}$ to 4 in. in size with total length of 6 miles. These systems serve sprinkler heads and hose connections throughout the garden areas. Most of the pipe is bare but a portion was reconditioned and given asphalt dip. The systems were placed in the ground by Construction Division forces during the period July 1938 to May 1939, and put into service as soon as completed.

Sanitary Force Main.

This consists of a trunk line extending full width and length of the Island with three feeders. It transmits sanitary sewage pumped into it from 14 collection sumps to the sewage disposal plant at the northeast corner of the Island. It is operated at a maximum pressure of 23 lb. per sq.in. It is composed of 6- to 16-inch welded steel pipe with a total length of 2 miles. The pipe was hot asphalt dipped but not uniformly preheated. It was laid by contract October 1, 1937 to January 18, 1938. The system was put into preliminary gravity operation in early May, 1938.

Gas Distribution System.

This is a partially interconnected grid consisting of 1- to 4-inch pipe with total length of 5 miles laid in the same trench with the domestic water pipes and at a distance of 8 in. above and to one side. It is supplied from the Pacific Gas & Electric Company's

natural gas system via 4-inch pressure main under the Bay from the Key Route Mole delivering at a pressure reducer at the southeast corner of the Island. It is operated at a pressure of 10 lb. per sq.in. and serves the various Exhibition Palaces, exhibitors' buildings and concessions. Twelve thousand feet, principally in the larger sizes, is standard black steel screw-connected pipe without protective covering. The remainder, principally in the smaller sizes, is standard black steel with welded connections primed with No. 3972 Pabco Primer and wrapped with one layer of Pabco Floatine (asphalt)

TABLE 4

Calculated Life of Steel Pipe at Treasure Island

SIZE OF PIPE	SHELL THICKNESS		CALCULATED LIFE IN YEARS*	
Inches	*Gage No.*	*Inches*	*Minimum*	*Average*
16 O.D.	10	.1406	.84	1.31
12 O.D.	12	.1093	.65	1.02
10 O.D.	12	.1093	.65	1.02
8 O.D.	14	.0781	.46	.73
6 O.D.	14	.0781	.46	.73
4 O.D.	16	.0625	.37	.58
4 I.D.	Standard	.237	1.41	2.22
3 I.D.	"	.216	1.27	2.02
2½ I.D.	"	.203	1.21	1.90
2 I.D.	"	.154	.92	1.44
1½ I.D.	"	.145	.86	1.35
1¼ I.D.	"	.140	.83	1.31
1 I.D.	"	.135	.80	1.26

* Number of years elapsing between installation of bare pipe and first leak due to corrosion.

impregnated rag felt. The whole system was installed under contract as bare screw joint pipe January 10 to April 10, 1938. Due to injury to the pipe, and particularly the fittings, by traffic during heavy exposition construction activities, and also because of the rapid advance of corrosion (Table 4), it was later decided to replace sizes less than 3 in. in diameter with the wrapped welded joint pipe. This was done by Construction Division forces November 15 to December 12, 1938, a total of 14,500 ft. being laid. Gas was turned into a portion of the system November 23, 1938, and progressively into the remainder up until the end of December.

Fountain Circulating Systems.

These consist of the piping required as pump suction and discharge lines to serve ornamental fountains from fountain basins. It also includes the piping in the Lagoon circulating system. Much of it is buried in the soil. The piping varies from 4 to 10 in. in size and has a total length of over 1.5 miles. It is welded steel partly asphalt dipped and partly bare. The various fountains operate at different pressures varying from 30 to 100 lb. per sq.in. The piping was installed by contract during May, June and July, 1938. Operation commenced on the opening day of the Exposition.

Drainage Pumping Systems.

There are 16 of these systems located around the exterior periphery of the main palace buildings and the Lagoon, and at the Sunken Garden. They consist of $1\frac{1}{4}$-inch well points, of which there are 143, sunk to a depth of 25 ft., with risers connected to suction headers $1\frac{1}{2}$ to 3 in. in size delivering to self-priming drainage pumps discharging through 3-inch lines to storm sewers. The total length of piping is 2.5 miles. The pipe is standard black steel screw joint without protective covering. Installations were made by Construction Division forces during the summer of 1938, and were placed into immediate operation.

Telephone System.

The Pacific Telephone and Telegraph Co. has a network of lead cables extending along every street on the Exposition grounds and with connections to every building. This system was constructed beginning August, 1938, and additional services were being added for several days after the opening date.

Pipe Corrosion

The discovery that pipe corrosion by pitting was in active progress at Treasure Island was made July 22, 1938 when leakage was reported from the domestic water line on Avenue 2, south of the two hangar buildings. Upon investigation, eight or nine holes were found in an 8-inch No. 14 gage pipe within a distance of several hundred feet. The pipe was clean and bare in the vicinity of the holes, but elsewhere the dip was unbroken and firmly adhering. The holes were about $\frac{1}{8}$ in. in diameter with sharp edges and fresh metal exposed. There was no sign of rust except a reddish incrustation in

the sand adjacent to the pipe. A few clay balls were noted in the sand.

Thorough investigations were at once commenced and extended to all piping on the Island. Local areas of pipe surface were found throughout the domestic system where clay balls or clayey streaks in sand were in contact with pipe, and within which the dip had poor adhesion or was removed. In these areas the surface of the metal was blotched or indented with sharp-edged pits of circular or irregular shape. Where the pipe was in contact with clean sand the dip was generally intact and tightly adhering. The same condition was found to exist on the sanitary force main, although here the dip could be easily peeled off over large areas.

Inspection of bare standard pipe in the gas system showed extensive corrosion in the form of irregularly blotched and pitted areas. Corrosion in the gas piping appeared to be greatest in the vicinity of clay, although clayey sand adjacent to the pipe was frequently caked with reddish brown incrustation.

The high pressure system was apparently free from corrosion. As time went on, no leaks occurred in this system except at three spots where the wrap had been broken in handling and bare pipe was exposed. The first of these was discovered on the 10-inch No. 13 gage pipe on Avenue 2 south of the east hangar, August 17, 1938.

The results of an analysis of corrosion rates based upon this investigation are of interest. The first leaks in the asphalt dipped 8-inch No. 14 gage (.078 in.) welded steel pipe occurred 160 days after the pipe was backfilled. The first leak in the 10-inch No. 12 gage welded steel pipe occurred 303 days after backfilling. The maximum depth of pit on a sample of 12-inch bare standard black steel pipe removed October 18, 1938, 191 days after backfilling, was .068 in. A few pits were also reported to have been found in the latter $\frac{1}{8}$ in. deep. The resulting maximum rates of corrosion are:

8-inch No. 14 gage welded steel (first leaks)	0.178 in. per yr.
10-inch No. 12 gage welded steel (first leak)	0.132 in. per yr.
2-inch Standard steel pipe (deepest pit in sample)	0.127 in. per yr.
2-inch Standard Steel pipe (deepest pits reported)	0.234± in. per yr.
Average maximum rate of pitting	0.168 in. per yr.

The average depth of all pits in the sample of 2-inch standard steel pipe was .057 inches in 191 days, giving an average annual rate of 0.107 in. per year.

Assuming these rates for the various sizes of pipe installed on Treasure Island, calculated pipe life as shown in Table 4 is obtained for bare pipe exposed to Treasure Island soil conditions.

As time went on, it became apparent that these rates of corrosion were being attained throughout the domestic system. Total number of new leaks which initially occurred in this system was at the rate of five per week. This rapidly increased, and by the middle of September, when remedial measures were first applied, had mounted to 15 per week.

Cause of Corrosion

Concurrently with the investigation of pitting, a survey was made to determine its cause. Tests for electric potential between pipe and soil were made August 2 to 4, 1938 by the Division of Water Supply and Sanitation, using a voltmeter and sensitive galvanometer temporarily loaned by the San Francisco Water Department. Potential was measured at 120 points on the domestic water, gas and high pressure systems. It was found that pipes were positive to soil (electric current flow from pipe to soil) at all points except along a sandy area free from clay on the western side of the Island. Observed values for potential ranged from 50 to 200 millivolts. Potential was noted only from bare metal, there being no potential difference between domestic water pipe and soil where the asphaltic dip was intact or between wrapped high pressure pipe and soil. Tests on the latter were made both at hydrants where bare metal was exposed and on wrapped sections.

Thorough investigation was also made of the possibility of electrolysis from stray d.c. electric currents. It was found that there were no d.c. circuits on the Island, nor any d.c. circuits leading to the Island. Subsequent tests made upon the water main from Yerba Buena Island and the gas main from Key Route Mole showed absence of appreciable electric current flow through these potential conductors.

Conclusion was reached that the cause of pitting was soil corrosion by galvanic action induced by the difference in potential between well-drained sandy areas and saturated saline clay. The pipes acted as conductors picking up current from sandy areas and

discharging it locally into clay balls or other clay bodies with resultant pitting at the points of discharge. The pitting action results from ionization of the metal in contact with soil solution, the metallic particles being carried away from the pipe in the soil solution and deposited in the adjacent soil where it subsequently oxidizes, forming incrustation. Such action is frequently encountered in long pipe lines where differences in soil potential develop "line currents" which cause rapid local pitting at discharge areas in low ground which are alkaline or saline and more or less saturated.

Cathodic Protection

Gas, oil and water companies operating long pipe lines have had great success during recent years in overcoming soil corrosion from "line currents" by use of cathodic protection. These lines have usually been isolated from other lines and located in natural soils characterized by homogeneity over large areas.

At Treasure Island the situation is more complicated and possesses unusual physical obstacles to the successful application of cathodic protection. Fundamental difficulties are:

(1) *Multiplicity of piping.* There are seven adjacent and more or less superimposed distribution pipe systems and a network of lead-covered telephone cable. Several of these systems were later found to have numerous unknown points of contact.

(2) *Diversity of piping.* Electrical conductivity differed widely due to great differences in area of metallic cross-section and differences in joint resistance. Also there was greatly differing electrical resistance of pipe covering which varied from bare pipe to pipe completely protected by dip and wrap.

(3) *Heterogeneous character of soil.* In respect to electrical resistance and corrosion, the utmost confusion is caused by the occurrence of moist saline clay masses surrounded by leached drained sand giving rise to innumerable small galvanic couples.

In spite of these difficulties it was recognized that regardless of complexity the essential principles applying to long pipe lines would also apply to networks. The alternative was to open up the pipe trenches and wrap the pipe, a very expensive and time-consuming operation which at this stage of Exposition construction would have been practically impossible. Cathodic protection offered the possibility of rapid attainment of results with minimum interference with Exposition construction activities and at relatively low cost.

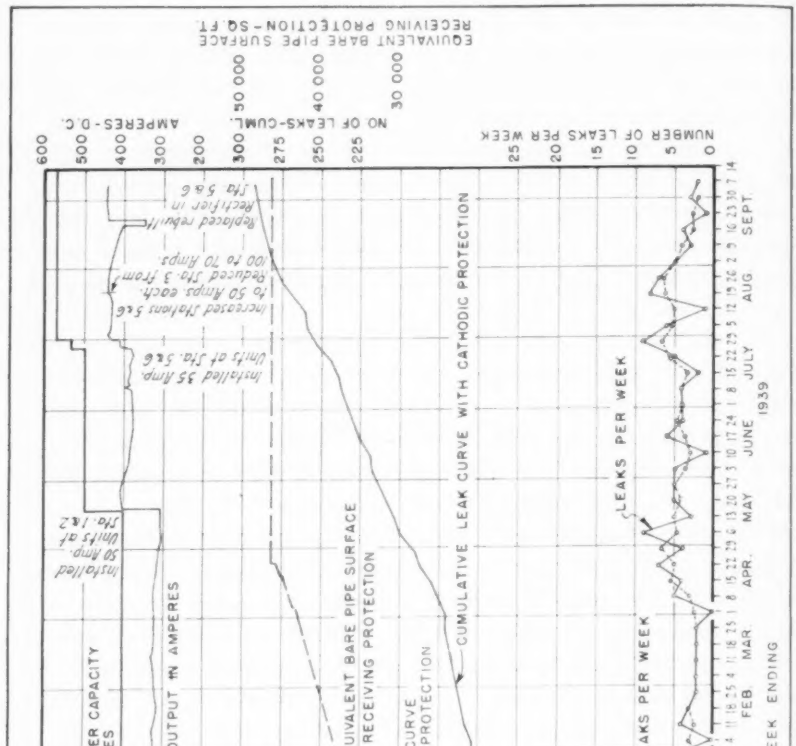

FIG. 3. Cathodic Protection at Treasure Island: record of leaks, rectifier capacity and output, and surface area of bare pipe protected

The Director of Works, after weighing pros and cons, authorized the Division of Water Supply and Sanitation to proceed with preparation of plans for cathodic protection for all underground pipe lines on Treasure Island on August 11, 1938.

Experience in the practical application of cathodic protection has been rapidly accumulating, and before commencing the design of installations at Treasure Island, recent technical literature was reviewed and the technical staffs of several large organizations operating pipe lines were consulted in order to obtain the benefit of most recent experience.

Plans for four stations were completed September 2, 1938, and installation commenced immediately. The first unit was in operation September 9, and four complete units were in operation October 10, 1938. An immediate reduction in new leaks occurred, and by December 18, 1938 the number of leaks had dropped from an average of ten per week to zero. A complete progress record including the number of leaks weekly and cumulative, total installed d.c. rectifier capacity and output, and equivalent area of bare pipe protected, is assembled in Fig. 3.

The corrosion of a metal pipe in contact with soil by galvanic action duplicates the process which goes on in an ordinary wet cell battery. The electric current is direct. Soil moisture acts as the electrolyte. The pipe acts both as the wire circuit connecting the binding posts and as the two electrodes in contact with the electrolyte. In a battery, corrosion occurs at the electrode from which the current flows. This electrode is called the anode and the corrosion is called anodic corrosion. The electrode to which the current flows is known as the cathode and does not corrode. In a pipe line those portions in contact with low resistant soil, such as moist alkaline or saline clay, act as anodes and suffer anodic corrosion. Electrical potential of the pipe is here positive to the soil. Portions of a pipe line in high resistant soil such as dry sand act as cathodes and do not corrode. Electrical potential of the pipe is here negative to the soil.

Cathodic protection consists of rendering all portions of the pipe negative to the soil, changing anodic areas to cathodic areas and thus preventing corrosion. Cathodic protection of pipe lines is accomplished by introducing direct current of proper intensity into the surrounding soil through anodes consisting preferably of pieces of used heavy pipe buried in the soil at a point some distance from the pipe line. The current flows into the soil from these anode pipes,

actively corroding them in the process, and thence flows through the soil and back to the pipe to be protected, converting anodic areas to cathodic. If the current is sufficient in amount and properly distributed, corrosion ceases.

When protecting long pipe lines, stations are spaced at proper intervals for the installed capacity to render the soil positive to the pipe at all points between. Location of stations for protection of pipe grids is more difficult, particularly where there are sections of bare pipe. The latter tends to "hog" the current and deprive adjacent lines with some degree of covering of any protection. Initial station location for pipe grids must be made somewhat arbitrarily and inadequately protected sections located by soil to pipe and pipe line current tests after operation commences. On the basis of such tests improved current distribution can be obtained by sectionizing bare pipe circuits, by use of resistance joints, and by introduction of controlled resistance into return leads.

Design of Stations

In the design of cathodic protection installations at Treasure Island, the following basic data were used:

(1) Sources of direct electrical current were provided in amount sufficient to render the soil electrically positive to piping at all points with a minimum potential between soil and pipe of 0.3 volts and a minimum current density of 15 milliamperes per sq.ft. of exposed bare pipe surface.

(2) The required total current capacity to give protection to piping was determined approximately by assuming an exposure factor for each type of pipe based upon the efficiency of the pipe covering and applying these factors to total square feet of surface of each type of pipe, thus obtaining a total equivalent area of bare pipe. Exposure factors were assumed as follows:

High pressure mains (wrapped)	.02
Domestic water mains (hot dipped)	.10
Sanitary force main (dipped)	.08
Gas mains (bare)	1.00
Gas mains (wrapped)	.02
Garden sprinkler pipe (reconditioned and dipped)	.25
Garden sprinkler pipe (bare)	1.00
Fountain and lagoon (dipped) circulating pipes	.10
Service connections (bare)	1.00

(3) Electrodes were, as often as possible, placed at a distance from the nearest pipe to be protected of not less than 40 ft. or fifty times the diameter of the pipe. They were located in the ground so that as much as possible of the exterior surface was permanently exposed to saturated soil. Experience with the electrically resistant sandy soil at Treasure Island showed the importance of following the latter rule rigidly.

(4) Electrodes were used with exterior surface sufficient to give a maximum current density of 0.10 amperes per sq.ft. This has been found sufficient to prevent drying out and baking of adjacent soil. In the case of extension of vertical anodes at Station No. 1 downward

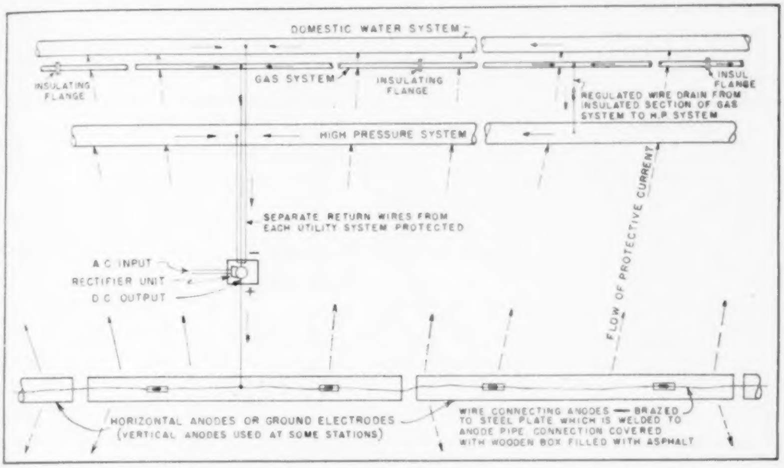

FIG. 4. Layout of Typical Cathodic Protection Station

into saturated soil, a maximum current density of 0.25 amperes was used because of low soil resistance. Total weight of metal required to withstand corrosion was computed on the basis of 20 lb. per ampere per year.

Layout of a typical cathodic protection station as installed at Treasure Island is shown in Fig. 4.

Rectifiers

Various sources of potential were investigated including d.c. generator sets and a.c. current with rectifiers. The latter is a device for transforming alternating current of lighting frequency and voltage to low voltage and then rectifying it to direct current. As the

Exposition Company had a.c. current distribution leads throughout the area occupied by pipe lines, this source was used. Both copper oxide and selenium rectifiers were considered. The former have the disadvantage of accelerated heating under increasing load and limited overload capacity. Selenium rectifiers are free from this and in general give higher efficiency in operation. They were reported to be giving highly satisfactory service on two large pipe line systems. The type selected was the Cathodic Corrosion-Eliminator with rexselen rectifier elements.

The total required rectifier capacity was estimated as 460 amperes from the initial area of equivalent bare pipe needing protection at

TABLE 5

Cathodic Protection Load in Terms of Equivalent Bare Pipe

PIPE SYSTEM	INSTALLATION PERIOD	EQUIVALENT BARE PIPE PROTECTED—SQ.FT.			
		Initial 10/14/38	12/12/38	4/1/39	4/25/39
High pressure	8/20/37–2/28/38	3,073	3,073	3,073	3,073
Domestic water	1/10–4/20/38	6,493	6,493	6,493	6,493
Sanitary mains	10/1/37–1/18/38	2,530	2,530	2,530	2,530
Gas (original)	1/10–4/10/38	15,934			
Gas (revised)	11/15–12/12/38		9,930	9,930	9,930
Garden sprinkler	July '38–May '39	2,716	3,000	10,000±	10,640
Fountain and lagoon circulation	May–July 1938				1,564
Water services	Aug. '38–May '39		6,000±	8,000±	8,850±
Gas services	Oct. '38–May '39		2,200±	3,000±	3,350±
Totals		30,746	33,226	43,026	46,430

the rate of 15 milliamperes per sq.ft. (Table 5). An initial purchase of four 8-volt 35 d.c. ampere units was made with 50 ampere transformer capacity. Tests for range and magnitude of protection made after installation of two of these units, with connection to the high pressure and domestic systems, showed that larger capacity units would be required. On the basis of these tests, the 35-ampere units were ordered converted to 8-volt 50-ampere capacity, and an additional purchase made of six 8-volt 50-ampere units. The initial installation was at four stations, each with two 50-ampere units. The total capacity of 400 amperes was 13 per cent less than the computed required capacity. This installation as completed Oc-

tober 10 was found sufficient to reduce leaks in the domestic system from a maximum of 15 per week to practically zero (Fig. 3).

Experience has shown that the most effective location for cathodic protection stations is in the "hottest" areas where soil corrosivity, current discharge, and pipe corrosion is the greatest. Due to the heterogeneous character of the dredger fill and the localized character of galvanic circuits, this rule is inapplicable at Treasure Island. As an alternative, stations were located with reference to area of pipe surface to be protected. In practical application, locations were

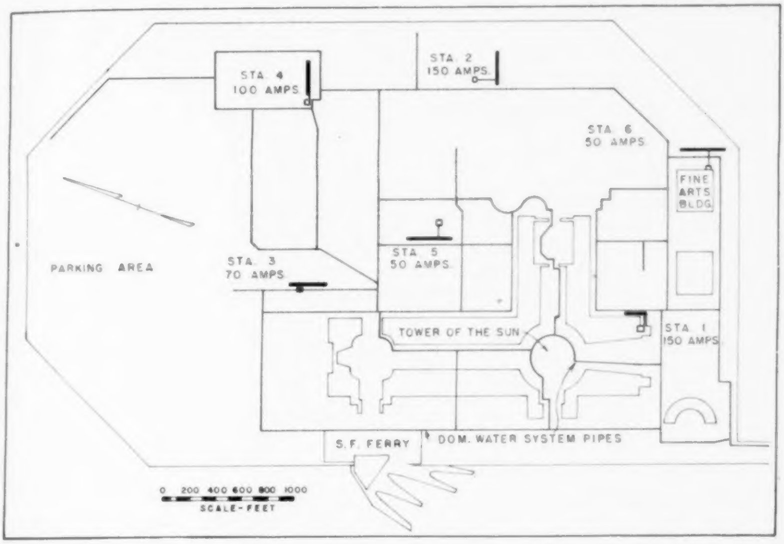

FIG. 5. Location of Cathodic Protection Stations and Domestic Water System

determined: first, by dividing the Island into four equal quadrants with respect to equivalent surface of bare pipe; second, by computing the position of the center of gravity of bare pipe for each quadrant; and finally, by selecting convenient locations near these points but off-center toward the corners of the Island. By this method it was planned to give each station an equal load of bare pipe to be protected without sacrificing flexibility, if it later became necessary to establish a fifth station in the center of the Island (see Fig. 5).

Rectifiers were of outdoor type (Fig. 6). Station No. 1 was installed in used space in one of the palace buildings, Station 2 was in

TABLE 6

Treasure Island Cathodic Protection Stations Record of Output and Current Density

STATION NO.	INSTALLED D.C. CAPACITY AT 8 V.	D.C. OUTPUT			SURFACE AREA OF ANODES	CURRENT DENSITY ON ANODES
	Amperes	Amperes	Volts	% Capacity	Sq.Ft.	Amp. per Sq.Ft.
January 20, 1939						
1	100	86	4.75	86	406*	0.21
2	100	90	7.50	90	708	0.13
3	100	84	6.83	84	708	0.12
4	100	68	10.0	68	708	0.10
Total.....	400	328		82		
May 26, 1939						
1	150	139	7.3	91	406*	0.34
2	150	131	10.1	87	708	0.18
3	100	66	6.3	66	708	0.09
4	100	72	9.4	72	708	0.10
Total.....	500	408		82		
August 7, 1939						
1	150	114	8.3	76	406*	0.28
2	150	116	9.7	77	708	0.16
3	100	57	5.7	57	708	0.08
4	100	80	9.0	80	708	0.12
5	35	35	1.8	100	472†	0.07
6	35	32	2.0	91	472†	0.07
Total.....	570	434		76		
September 25, 1939						
1	150	97	8.6	65	406*	0.24
2	150	98	10.0	65	708	0.14
3	70	69	6.4	98	708	0.10
4	100	84	8.6	88	708	0.12
5	50§	49	3.0	98	472†	0.10
6	50§	46	3.0	92	472†	0.10
Total.....	570	443		78		

* 12 ft. of pipe below water table.

† 16 ft. of pipe below water table.

§ Rectifier units moved from Sta. 3 after replacement of selenium plates.

a large transformer vault, and Station 4 was in a large abandoned manhole, all of which locations had good ventilation. Station 3 was placed in a specially constructed manhole of small size with inadequate ventilation. Rectifiers at this station gave trouble by heating, and although the ventilation was ultimately improved, the units after ten months service were so reduced in efficiency that it became necessary to rebuild the unit with new selenium plates.

A record of rectifier capacity and output at various typical dates is presented on Table 6.

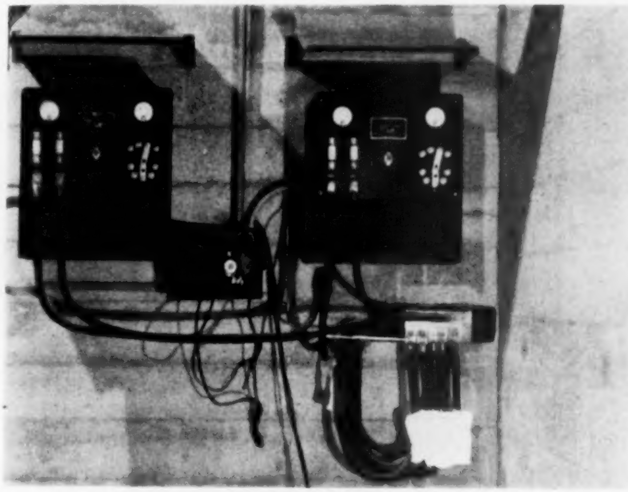

FIG. 6. Typical Rectifier Unit, Cathodic Protection Station 2

Anodes

The ground electrodes, or anodes, at each station consist of 21 12-foot lengths of used 10-inch standard black steel pipe. The total length of pipe was designed to give sufficient metal for two years of operation. The size was selected so as to give a current density of 0.10 amperes per sq.ft.

At Station 1 the pipes were set in vertical holes spaced 10 ft. and jetted down to a depth of 13 ft. This was a garden area and an important traffic point where it was impractical to dig trench. The pipes penetrated two to three feet below the plane of saturation. The initial output of the station was less than 40 per cent of installed capacity and tests showed high electrical resistance between the

electrode and remote drained soil above the plane of saturation. This was probably caused by the low moisture content of the sandy soil even in the capillary fringe. Attempts were made to reduce the soil resistance by introducing ammonium sulfate solution around the outside of the anode, both alone and combined with bentonite, but without permanent success. The sand was too coarse to hold the solution above the water table and bentonite was used as an admixture to render the sand more retentive. The bentonite deposited upon the sand opposite pipe perforations, however, and closed them. It was finally found necessary to deepen the electrodes at this station. This was done by drilling inside the 10-inch pipes to a depth of 20 ft. and placing 20-foot lengths of 5-inch standard pipe in the holes. The output of the station immediately jumped from 40 amperes at $9\frac{1}{2}$ volts to more than 90 amperes at 8 volts, with decrease in external resistance from 0.22 ohms to 0.05 ohms.

Stations 2, 3 and 4 were more remote from construction activity and the pipe lengths were laid horizontally end to end in trench excavated to saturated soil. At Stations 2 and 4, water level had been drawn down by drainage pumps, and it was necessary to excavate to a depth of nearly 12 ft. At Station 3 the depth was only 6 ft.

As time went on, the effect of fluctuating water level was evident in the output from some of the stations. It was found necessary to schedule the operation of adjacent drainage pumps so that ground electrodes were kept submerged but without water levels rising high enough to drown tree roots or cause uplift beneath the clay lining of the Lagoon.

The working current density on anode pipes in amperes per sq.ft. is indicated for several typical dates at each station in the last column of Table 6. With the exception of Stations 1 and 2, these values agree closely with the design assumptions. Current density at these two stations has been increased over that originally intended by the addition of a third 50-ampere unit. It is possible that the high current density at these stations is the cause of the marked decrease in output which is occurring. As between vertical and horizontal anodes, however, there is no difference in output.

Conductors

Electrical conductors were installed at each station from the positive side of rectifier to distributor cable in ground electrode trench

and thence to anode pipes; and from the negative side of rectifier to the pipe systems being protected. Cable is single conductor stranded N.E.C. rubber insulated copper size 2/0 and 4/0 A.W.S. All cable splices and ends were taped and painted with two coats of asphalt paint.

Connection to anode pipes was made by removing insulation from copper cable for a distance of 5 in., and brazing the bare copper to a 3 by 4-inch steel plate, which in turn was spot welded to a fresh metal pipe surface near the top of the pipe (Fig. 7). This connection and adjacent bare cable were painted with primer, and covered

FIG. 7. Cable Connections at Anode Pipes

with a 5 by 8-inch protective wooden box strapped to the pipe. The box was then filled with hot asphalt. This thorough protection of the anode connections is very important in order to prevent local corrosion of the wire with loss of use of the anode. In the case of the 20-foot vertical electrodes, connections were made inside the pipe at both top and bottom to insure against loss of the electrode in case the pipe was severed just above the water table by excessive corrosion. Cables connecting horizontal electrodes were connected to each pipe at two points on the outside (Fig. 7).

Negative connections to pipe systems were made through separate

leads brazed to the pipe of the nearby protected pipe systems. The connections were protected from corrosion with two coats of asphalt paint. Separate leads were necessitated by the great differences in character and electrical resistance of pipe covering in the different systems. Separate leads permitted partial regulation of protection on each system by introduction of electrical resistance in the conductor. To bring about a complete balance in current, however, and equalization of protection among the various systems, bonding was required.

Bonds

One of the most important but yet most intricate problems involved in establishment of cathodic protection at Treasure Island was the placing of electrical bonds. These were of two types, low resistance copper cable, and cable conductor with controlled resistance cells. The primary purpose of bonding was to provide a more uniform current distribution. Provision for adequate d.c. current capacity, even if introduced into the ground at local centers of gravity of equivalent bare pipe, would not give uniform protection unless the current reached all portions of the various pipe networks. Current pick-up from the soil is generally proportional to the resistance of pipe covering which varies from a nominal value for bare pipe up to very high values for wrapped pipe. At Treasure Island the gas system in its original condition was entirely bare and represented 50 per cent of the total pipe surface to be protected (Table 5). Without bonding the gas system would absorb an unduly large proportion of current at the expense of the domestic water system, and so render cathodic protection of the domestic system ineffective.

For bonding to be effective in an assembly of pipe networks, there must be an insulated conductor providing free flow back to the negative side of rectifier units. The high pressure system is ideal for this purpose as it is insulated from the soil by the wrap, has a large metallic cross-section, and forms a closed network covering all piped areas. This system was therefore selected as a collecting bus. Other systems were bonded to it at widely separated points, some with low resistance cable and some with resistance coils, depending upon the observed current flow, and thus drawing protective current to all parts of the Island. In order to render the high pressure system fully effective, tests showed the need of placing low resistance copper cable bonds across flexible Dresser couplings, which had been

inserted in the high pressure system to take up uneven settlement or temperature movement. These bonds conducted current across the joints which offered resistance to free flow. Eleven of these, of which there was record, were bonded, but it is possible that there were others.

Another preliminary step which was found necessary was the separation of domestic and gas piping and the lead covered telephone cables, so as to render them electrically independent. For economy, water and gas mains had been laid in the same trench, and in the rush of construction activities many water and gas service stubs had been laid in contact with each other, with the mains, and in some instances with telephone cables. In order to drain these systems through the high pressure network, it was necessary to isolate them. This was accomplished to as great a degree as possible by spotting all known pipe crossings from maps and digging down to the pipes. Where there was contact, pipes were separated by driving wooden wedges between them. Many additional contacts, particularly of services, were found by use of a radio pipe finder in locating pipe crossings. These were similarly separated, as well as all contacts between service pipes and telephone cable. The total number of crossings excavated was 124, of which 44 were found in actual contact. It is possible that there are other contacts which were not found.

These preliminary steps having been completed to the extent of available information, bonding to the high pressure system from each of the other systems was undertaken in accord with the results of current tests.

The domestic system, with initially connected garden sprinkler lines, was found to receive adequate protection through the four cable leads to the rectifier stations and at the four cross-connections with the high pressure system. No bonding of this system was attempted.

The sanitary force main was also found to be adequately protected by the four cable leads to rectifier stations.

The gas system presented more of a problem. Constructed initially of bare pipe, it was later reconstructed by replacing smaller sizes with wrapped pipe. Tests showed that current picked up by bare portions returned to the rectifier stations without developing enough potential through the wrapping to give protection. This condition was corrected by installing ten insulated couplings in the system located so as to separate the bare from the wrapped portions.

Each section was then connected either to a rectifier station, or to the high pressure system if the former was not conveniently located. Five bonds to the high pressure system were installed in addition to the four leads to rectifier. Resistance coils were placed in each of the leads or bonds, adjusted in amount as shown by test so as to prevent the picking up of excessive current in any run of bare pipe. The latter is screw connected and the joints may develop resistance to electrical flow forcing the current around the joint through the soil. This would produce local pitting at each joint. To prevent this, steel strap jumpers were spot welded across each joint.

The lead telephone cables of the Pacific Telephone & Telegraph Company were bonded to the domestic water system at three points where the cables were positive to other structures and drainage seemed advisable.

Tests

All electrical tests were conducted by the Bureau of Tests and Inspection, Pacific Gas & Electric Company, under special arrangement with the Exposition Company. The primary purposes of tests were:

(1) To check the installed rectifier capacity at each of the four cathodic protection stations to determine whether sufficient to render the soil electrically positive to the pipe to the extent of 0.3 volts and a minimum of 15 milliamperes per sq.ft. current density.

(2) To determine necessity and location for bonds and to adjust resistances in leads and bonds so as to distribute properly the current over the various pipe systems.

(3) To determine the best location for additional cathodic protection stations and additional bonding, if and when necessary.

Supplemental tests were also made to check the possibility of stray d.c. currents reaching Treasure Island from distant sources, to locate pipe crossings where there might be contact, to determine soil resistance of typical soils and of soils surrounding electrodes, and to determine rates of pipe corrosion by use of metal coupons placed in the soil.

Tests were commenced September 14, 1939 after initial installation of 35 ampere units at Stations 1 and 3. The supplemental tests were made prior to October 5. Items 1 and 2 of primary tests (as cited above) were carried on intermittently during the period

October 10 to December 4, and Item 3 during the middle of May, 1939.

Primary tests consisted principally of determining the magnitude and direction of soil current flow due to galvanic action between the soil and the pipe, and the magnitude and direction of electric current flow in long runs of pipe.

Soil current measurements were made with a McCollum earth current meter and special non-polarizing copper sulfate electrode. Measurements were made by stripping the pipe covering within an area 11 in. long and one quarter the pipe circumference wide, cleaning the exposed steel and replacing the soil against the pipe. The electrode was then placed in the soil near the bared pipe surface and the potential drop across the terminals of the electrode measured. From this the current flow between soil and pipe was computed.

Pipe current measurements were computed from the potential drop between fire hydrants or valves determining the resistance of of the pipe from the cross-sectional area, the length of pipe, and the potential drop. In this manner pavement cutting was avoided.

Corrosion coupon tests were made upon strips of $\frac{1}{4}$ by 3 by 6-inch steel plates which were cleaned, numbered and weighed. They were placed in the soil in pairs, 18 in. apart and 12 in. from the side of the pipe and backfilled. The control coupon is not electrically connected to the pipe. The other known as the pipe coupon is connected to the pipe by a short length of insulated copper cable soldered to the pipe. Cable connections to pipe and coupon are covered with asphalt to prevent corrosion and local pitting. The coupons are removed after a period of six months and weighed again. The condition of the control coupon is indicative of corrosivity of the soil alone and that of the pipe coupon of pitting due to galvanic action. Results of coupon tests are not yet available.

The results of tests made during October and November, 1938, after installation of 400 amperes of d.c. current, indicated soil current density from soil to the high pressure system varying from 5 to 73 milliamperes per sq.ft. of exposed pipe surface. The average was less than 15, the design value.

Current distribution in pipe networks was generally good but with wide local variations. The latter were probably caused by undiscovered accidental contacts, high resistance couplings, and possibly by short circuiting through buried clay ridges. Pipe current flow in

the high pressure system varied from less than 1.0 amperes at points distant from cathodic protection stations to values greater than 8 amperes near the stations.

Extension of Cathodic Protection

At the date of installation of the four original cathodic protection stations, all water mains had been laid, but very few of the garden sprinkler lines or service pipes had been placed in the ground. After November 1, 1938 these went in rapidly, and by April 1, 1939, the area of equivalent bare pipe had increased from 30,700 to 43,000 sq.ft. (Table 5 and Fig. 3). The discovery of corrosion leaks in one of the fountain circulating systems early in February, led to decision to extend cathodic protection to all fountains and also to the lagoon circulation system. These connections were made during April. The final area of equivalent bare pipe receiving protection on May 1 1939 was 46,400 sq.ft. This was 40 per cent greater than had been originally planned for, due in large part to the inclusion of the fountain circulation systems, the added sprinkler systems required for landscaping unsold areas, and the extensive system of distribution laterals required by several concessionaires who at the last moment purchased large ground areas.

Concurrently with the increase in services and sprinkler systems, the weekly leakage rate, which had been zero in mid-December, began to climb, and by April 25, when the fountain systems were tied in, it had reached an average of over five per week (Fig. 3). The new leaks occurred principally along the outer margins of the quadrants protected by Stations 1 and 2, and in the vicinity of the point common to the four quadrants. Renewed corrosion activity was due both to increased area of pipe being protected, and to decreasing efficiency of rectifiers with resulting smaller output.

As the first step toward control of renewed corrosion, the two spare 50-ampere rectifier units were installed at Stations 1 and 2 on May 18, 1939. Soil and pipe current tests made immediately thereafter showed that in three areas of active corrosion the domestic water system was still inadequately protected, the pipes being negative to the soil but the current density too low, being less than 1 milliampere per sq.ft. of exposed pipe surface. Decision was therefore made to install two new 35-ampere stations in the most active corrosion areas, one at the center of the Island back of the Argentine Building, and the other at the southeast corner opposite the East Hangar

Building. The third hot area at the South Elephant Towers was to be protected by local bonding of the domestic to high pressure system.

The two new Stations 5 and 6, were designed with vertical anodes composed of nine 8-inch standard steel pipes 25 ft. long sunk vertically into 10-inch auger holes spaced 35 ft. The lower 16 ft. of the anodes at both stations was in saturated material, principally sand. Cable connections were made at top, mid and bottom points on the inside of the pipes through windows cut through the pipe wall and later closed by spot welding. The anodes were designed for current density of less than 0.10 ampere per sq.ft. of pipe surface in saturated soil, thus allowing for added capacity if necessary. Installation of the two 35-ampere units and the bonds was completed late in July.

The area served by Station 3, having always been comparatively free from leaks, it was later decided to move the two 50-ampere units to the new stations and use the new 35-ampere units at Station 3. This change resulted in marked increase in output at Station 3 (Table 6), and upon investigation it was found that the selenium plates in the 50-ampere units had greatly deteriorated, probably due to over-heating prior to installation of adequate ventilation. The units were returned to the factory for rebuilding, and when installed at Stations 5 and 6 on September 22, gave their normal output. These additions and changes resulted in increase of total output from cathodic protection stations to nearly 450 amperes and decrease in number of new leaks to two per week (Fig. 3 and Table 6).

Leak Record

In connection with cathodic protection operations a careful record has been kept of new leaks, the data including date, location, pipe system and size of pipe. From this record has been prepared the two graphs at the bottom of Fig. 3 entitled, "Leaks per Week" and "Cumulative Leak Curve." These graphs commence August 1, 1938, a few days after the first leaks were discovered. The number of leaks discovered weekly is rather erratic, and the weekly curve has been smoothed out by drawing an average curve representing means for each three consecutive weeks.

The appearance of moisture or water at the surface of the ground, followed by opening up of the trench and repair of the leak, has been the evidence of new leaks. Undoubtedly numerous leaks have never been discovered. When excavations were made for the gas line re-

placements along the domestic water lines, nearly 30 leaks were found in the latter in a distance of approximately 10,000 ft., the escaping water having been absorbed by the sand without appearing at the surface (Fig. 3). Night measurements made during August 1939 indicate that the total leakage from the domestic system is 200 gallons per minute. Much of this may be from undiscovered corrosion leaks. The total number of these leaks cannot be estimated and no attempt has been made to include them in the leakage record. The following discussion of leakage is based entirely upon discovered leaks.

Leak Distribution

Among the various utility systems, leaks were confined almost entirely to the domestic water pipes. Out of the total of 291 leaks

TABLE 7

Relation of Leaks per Week to Total Output of Cathodic Protection Stations

DATE	AVE. NO. OF LEAKS PER WEEK	AREA OF EQUIVALENT BARE PIPE*	RECTIFIER OUTPUT*	CURRENT DENSITY PER SQ.FT. OF BARE PIPE*
		Sq.Ft.	*Amperes*	*Milliamperes*
12/25/38	1	34,500	320	9.25
5/13/39	5	44,150	320	7.25
7/15/39	3.5	46,400	390	8.3
9/16/39	2	46,400	430	9.2

* Average during eight preceding weeks.

occurring up to October 1, 1939, 285 were on the domestic water system and only 6 on the high pressure system. The latter were all at points where bare pipe was exposed, either by injury to the wrapping or at field joints on short steel connections to fire hydrants which were backfilled without adequate covering. No corrosion leaks have been reported in the gas system.

The geographic distribution of leaks was spotted and concentrated locally. Prior to April 1, 1939 the hot spots were along the south sea wall, in the center of the Island, and in the Gayway. After April 1, the Gayway ceased to give trouble but several new hot areas developed principally along the western front opposite the Elephant Towers and the Administration Building. Considering pipe footage, leaks prior to April 1, 1939 occurred along sections of domestic water pipe totaling 10,600 ft. or 27.5 per cent of the total

in the system. Between April 1 and October 1, 1939 leaks occurred along 7,200 ft. of pipe of which 3,500 ft. had not previously experienced leaks. The total length of pipe experiencing leaks at any time was 14,100 ft. or 36.5 per cent of the total system. The geographic distribution of leaks was probably controlled by the local character of the fill material.

The leak record in conjunction with the equivalent bare pipe and rectifier output records furnishes a basis for determining the soil current density in terms of milliamperes per sq.ft. of exposed pipe surface which is necessary for complete control of corrosion under Treasure Island conditions. Experience at the Island shows that it requires about eight weeks for the application of d.c. current to the soil to become fully effective in reducing corrosion to a minimum. This is evidenced by the attainment of zero leaks December 15, 1938, about eight weeks after the initial installation of 400 amperes on October 12, and by the reduction to two leaks per week eight weeks after the addition of 100 amperes May 18, 1939 (Fig. 3). Selecting four typical weekly leak rates during the one-year period in which cathodic protection has been in operation, and computing the average area of equivalent bare pipe and average rectifier output during the eight weeks preceding each of the respective leak periods, the data shown in Table 7 are obtained.

Assembling graphically on Fig. 8 these values of leaks per week and current density, it appears that the current density required to control corrosion completely at Treasure Island is 10 milliamperes per sq.ft. of exposed bare pipe surface. In comparison with this, the value of 15 was used in design, this having been chosen after review of experience on other pipe lines where homogeneous areas of alkaline and salty soil were encountered. It appears that although corrosion activity is intense at Treasure Island it is locally concentrated, and that the total amount of current required for protection is not as great relatively as for large corrosive areas composed of homogeneous natural soil. This conclusion is supported by the geographical distribution of leaks.

Cost of Leak Repair

During the first six weeks of the leak record there was no cathodic protection, and the cumulative curve gives a basis for laying out and projecting over a longer period a cumulative leak curve without cathodic protection. This curve indicates a rapid acceleration

in the number of leaks per week, its equation being of the form $L = 1.82\ T^{1.66}$, where L = the total number of leaks, and T the time in weeks from August 1, 1938. From this equation has been computed the number of leaks which would have occurred annually during a two-year period, and also the cost of repairing leaks at the current cost to the Exposition of $7.50 per leak. The results are shown in Table 8.

Compared with these repair cost figures, the cost of installing 570

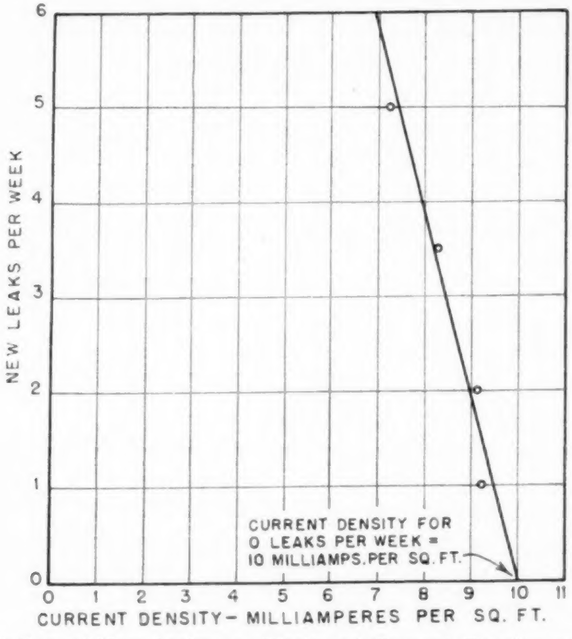

FIG. 8. Relation of New Leaks per Week and Current Density per sq.ft. of Equivalent Bare Pipe

amperes capacity of cathodic protection, including equipment, labor and testing was $12,400 or $21.80 per ampere. From this it may be concluded that the decision to install cathodic protection was financially justified, since there were 18 months to run when corrosion leaks were first discovered and in addition the possibility of operating the Exposition during a second year. There was also the ever-increasing hazard of extensive breaks occurring with damage to property and possible life, should steps not have been taken promptly to control pipe corrosion.

Looking to another year of operation, it is considered that if output from present installed capacity is insufficient to reduce leakage to zero, it would be economy to repair pipe leaks, rather than construct additional stations, up to the rate of possibly five leaks per week. If this rate was exceeded prior to January 1, 1940 and the Exposition was to run for another year, additional expenditure for corrosion protection might be justified, either for installation of insulated joints to cut off garden sprinkler systems and extensive concessionaire services and thus reduce the load, or for more cathodic protection capacity.

Conclusions

(1) Treasure Island is a salt water dredger-fill composed of sand with occasional clay balls and local thin clay sheets. Subsequent to construction, salt was leached from the sand but was retained by the clay. These conditions produced rapid local corrosion by pitting in bare and asphalt-dipped steel pipe. The maximum rate of pitting was 0.168 in. per year and the average 0.107 inches.

TABLE 8

Cost of Repairing Leaks due to Corrosion

YEAR	TOTAL LEAKS	AVE. LEAKS PER WEEK	ANNUAL COST OF REPAIR	TOTAL COST OF REPAIR
First	1,283	25	$9,750	$9,750
Second	4,060	54	21,000	30,750
Third	7,960	75	28,650	59,400

(2) This excessive soil corrosion, affecting an assembly of eight co-existent utility networks at Treasure Island, has been successfully and economically controlled by application of cathodic protection.

(3) The number of new leaks per week in the domestic water system, which was the most vulnerable, was reduced from 15 to zero, and corrosion in all pipe systems was effectively controlled. This was accomplished by the installation of six rectifier stations with an output of approximately 460 d.c. amperes giving current density of 10 milliamperes per sq.ft. of equivalent exposed bare pipe surface.

(4) Rectifiers at cathodic protection stations having anode pipes with external surface in contact with saturated sand sufficient to give an average current density of 0.10 amperes per sq.ft., experienced no decrease in output over a period of one year. Those with

greater current density showed a steady decrease in output during the same period.

Acknowledgments

Cathodic protection installations at Treasure Island were designed, constructed, and operated by the Department of Works of which W. P. Day is Director. The Division of Water Supply and Sanitation, of which the writer is Chief and R. F. Lauenstein is Assistant Chief, was in direct charge. W. R. Van Bokkelen, Chief of Electrical Division, and W. H. Leland, Chief of Mechanical Division, cooperated in the work. Otto A. Knopp, Chief, and W. R. Schneider, Assistant Engineer, Bureau of Tests and Inspection, Pacific Gas & Electric Company; and H. A. Knudsen, Chief Electrical and Mechanical Engineer, East Bay Municipal Utility District, rendered valuable advisory assistance.

ABSTRACTS OF WATER WORKS LITERATURE

Key. **31:** 481 (Mar. '39) indicates volume 31, page 481, issue dated March 1939. If the publication is paged by issues, **31:** 3: 481 (Mar. '39) indicates volume 31, number 3, page 481. Material enclosed in starred brackets, ★[□]★, is comment or opinion of abstractor. Initials following an abstract indicate reproduction, by permission, from periodicals as follows: *B. H.—Bulletin of Hygiene (British); C. A.—Chemical Abstracts; P. H. E. A.—Public Health Engineering Abstracts; W. P. R.—Water Pollution Research (British); I. M.—Institute of Metals (British).*

ADMINISTRATION, PERSONNEL AND PUBLIC RELATIONS

Black-outs of Gas and Water Plants with the Method of Luminescence. Nikolaus Riehl and Ernst A. Fick. Gas-u. Wasser. **82:** 781. (Dec. 2, '39.) The method of luminescence consists of marking places of importance for continuation and supervision of the operation of a plant with luminous paint or enamel which emits light under continuous radiation of invisible ultraviolet rays. It eliminates necessity to darken windows with curtains. Markings are used to outline characteristic points on machinery, handwheels, instruments, stairs, railings, etc. Mercury vapor lamps with blue or black glass filters are used as source of ultraviolet rays. These emit rays with wave length of about 365 mμ. This type of ultraviolet rays does not cause burns on the skin and the slight effect on the eyes can be eliminated by use of yellow glasses. Commercial sizes of lamps have 80 or 120 W. (80 W. types are HgHQS300 or Meda 300 HQS, 120 W. types are HgHQS500 or Meda 500 HQS). An 80 W. lamp is sufficient for room up to 200 sq.ft. For illumination of small spaces, small bulb producing ultraviolet rays has been developed that uses only 25 M.A. The importance of this type of illumination lies in the fact that although light intensity of illuminated surface is greater than normally allowed during black-outs, the light is invisible from distances of 500–1000 ft., as it is limited to very small areas. This type of lighting can therefore also be used for illumination of outdoor signals or markings. An afterglow of the surface allows even some visibility in case the current goes out on the ultraviolet light.—*Max Suter.*

Legal Ownership of Water. Leo T. Parker. W. W. Eng. **92:** 1489 (Nov. 22, '39). Higher courts have consistently held that where a party has a prior right to a certain quantity of water he is entitled to it, but only to extent needed for use to which it was appropriated; when water wastes back or percolates from lands or otherwise leaves the control of the owner of such lands, it becomes free unappropriated water. Water may be sold separately from land,

because owner owns the water and not merely right to use it for a particular purpose. Well established law that a municipal corp. or other company, firm or person who expends money and labor to divert appropriable water from stream is entitled to its exclusive control so long as he is able and willing to apply it to beneficial uses. Person or municipal corp. may use water, discharge it, and then recapture it, if recapture is accomplished without detriment to lower water users. Various courts have held that lakes, pools and springs, located wholly upon and within the lands of person or corp. are appurtenant to and part of the land and belong exclusively to owners of the land. Modern laws, as adopted by different states, provide that all contracts for specified period to sell any lands, or any interest in or concerning them and contracts for leasing land are void unless contract or some memo. or note thereof is put in writing.—*Martin E. Flentje.*

Coordination of Pension Plans With Social Security Provisions. M. B. Folsom. Edison Elec. Inst. Bul. **7**: 527 (Nov. '39). Business executives and industrial relations men agree adequate pension plan is good business investment, borne out by experience and adoption of many plans during past few years. Exact statistics are not available. It is estimated that 900 plans are in operation. Many plans have been inaugurated since Social Security Act passed. Probably less than 20% of industrial employees are covered. Percentage of pension plans is higher in public utilities than other industries, undoubtedly due to smaller labor turnover—employees remaining until retirement age, and to enlightened attitude of management. Companies in business for years find employees reaching retirement age without means of support. Employer retains employee after period of usefulness. Discharge of employee would have bad effect upon public which it serves. Resultant pension cost is buried among other costs of business. Retirement of such employee makes way for younger and more efficient worker, stimulates entire organization, aids employer's reputation, attracts more satisfactory employees, and is, therefore, good business investment. A large company's experience with pension plans in this and foreign countries finds governmental plans give adequate subsistence to those in lower income groups, but are not adequate for majority of employees; hence, supplemental plans are necessary. Basic philosophy of revised Social Security Act is a social insurance basis instead of private insurance basis. Original act provided for large reserve fund and worker benefits in proportion to contribution. It became evident this was not a satisfactory solution. Revised plan entails no large reserve, eventually benefits financed from payroll taxes on employer and employee and general governmental revenues. Ultimately benefits may cost over 10% of covered payroll. 3% each on employer and employee scheduled in 15 or 20 years will not be sufficient, though present tax is sufficient for a few years. Experience has shown 40% of final pay is required for effective plan, higher for lower income group. Prior to 1925 very few soundly financed pension plans existed. There are two general types of plans; matched dollar or money purchase and fixed benefit plan. Under the money purchase plan, employer and employee contribute equally. Younger employee's dollar buys more than older. Employer knows his cost. Objection—employer's money would buy

more for younger than older employee, be necessary for employer to contribute heavily for past service of old employee. Fixed benefit plan more adequately meets demand of typical company, provides a definite annuity, 1% or 2% for each year's service for older employees. Employer's contribution higher, more adequate benefits for employees retired in next 20 years. Benefits must be provided for past service and accrued liability financed. It is sound industrial relations to finance cost of an annuity plan on a contributory basis, employee and employer contributing equally. Adequate plan, providing past and future service credits would cost employer about 5% of payroll, past service spread over 20 year period, in addition to Social Security taxes. Exact adjustment of plans already in force to coordinate them with the Social Security Act, requires separate treatment for each plan, as very few are alike. If no plan exists, or a company desires to adjust to the Social Security Act, an annuity consultant should be employed or one or more insurance companies offering group annuities.—*Samuel A. Evans.*

Filtration Plant Visitors. FRED E. SMITH. Pub. Wks. **70:** 12: 14 (Dec. '39). Purification plant lectures and demonstrations must be fitted to visitors, most of whom fall into 3 classes: (a) college students in science or engineering; (b) secondary school classes and such groups as Boy Scouts; (c) undergraduate nurses. At Cambridge, Mass., author first gives history of plant, then follows water through plant, varying technical descriptions given to meet needs of group. Reception of visitors and demonstration of plant operation important part of resident chemist's duties.—*Martin E. Flentje.*

Liability for Failure to Supply Water. LEO T. PARKER. Combustion. **11:** 6: 39 (Dec. '39). Four cases are cited where higher courts have consistently held that in operating water works plant, city is operating public utility, and must treat all alike within same classification, and make same charge for water used. Although water meter is not strictly accurate, municipality or water corporation not liable for cutting off water supply from consumer who refuses to pay reasonable amount for water actually used, and this quantity may be determined by reference to previous bills rendered. City is liable and cannot be relieved for its negligence in shutting off water. Consumer has right to recover damages, resulting from temporarily shutting off supply of water without expressed contract between water company and consumer. City is not liable in damages to plant owner whose property is destroyed by fire as result of negligence on part of municipal officials in failing to provide adequate water supply. Plant owner is entitled to be supplied with water, but is under a correlative duty to pay municipality, or water company, according to its rates and in manner described by its rules. Failure of owner to do so gives municipality, or water company, right to discontinue the supply of water. If state law entitles municipality, or water company, to a lien on the real property to secure payment for overdue water bills, seller of water may continue to supply water to delinquent consumers and later hold owner of the real property responsible for payment of bill. Under these circumstances municipality, or water company, may collect for water supplied

to tenant by either holding property owner liable or by cutting off the water supply *without notice* if property owner refuses to abide by reasonable rules.—*T. E. Larson.*

Colorado Public Utilities Commission. Three Eagles Company v. Brookside Water Company et al. Commission Ruling. Pub. Util. Fort. **31:** 60 (Jan. 4, '40). Complainant stated respondent water company formerly furnished water service to certain premises, and discontinued service after residences on premises destroyed by fire. Late schedule on file with commission provides description of territory supplied by respondent. This implies that the company will serve this territory, providing the required facilities. If impossible to secure these facilities company should limit its territories in accordance with its ability to serve; right to increase or decrease territory served would be for commission to determine. Respondent ordered to serve territory in question.—*Samuel A. Evans.*

War—Its Probable Effect on Water Companies. Charles Haydock. W. W. Eng. **92:** 1496 (Nov. 22, '39). The present war will materially affect our viewpoints and profoundly affect all business, including utility operations. If war is of short duration, its effect on our country will probably be of short duration. Prices generally rise throughout long wars. Decentralization of industry may develop as result of war. This would require expansion of water utilities. Ample supplies, surplus plant capacity and ample reserve of unemployed labor are on hand to meet war demands. Utility revenues will increase, water utilities however will probably be the least affected of all public utilities in respect to both increased revenues and expenses. Author believes it should be easier to secure rate increases than it was 25 yrs. ago. Public utilities are in much better position to avoid the detrimental effects of this war than they were at the beginning of World War; best hopes of minimizing in this country the disastrous effects of the European war, author believes, lie in our remaining neutral.—*Martin E. Flentje.*

The Washington Outlook for Utilities—1940. Francis X. Welch. Pub. Util. Fort. **25:** 3 (Jan. 4, '40). Year 1940 is bound to bring headaches to everybody in all lines of business and walks of life. Obvious reasons: war in Europe with repercussions on our national economy and public psychology; general election with various political angles. These are disturbing factors but not new to utility industries. By law of averages, theory of compensation, or other intangible force it appears a quiet year for utilities in Washington. It appears that neither Congress nor the Federal Commission is going to do much for or against the utilities. Extreme Left may criticize SEC, probably only words drowned out by hubbub of a strident session. There is a possibility of new taxes hitting one or more utility industries, probably only talk in Congress, minor revisions, probably nothing of vital importance;—reason, general elections. In the Supreme Court, from standpoint of quantity, not much is on docket of utility interest compared to last 3 or 4 critical years. Will the utilities be a campaign issue in 1940?—minor only. If President Roosevelt or ultra New Dealer on Democratic ticket, speeches about 'power

trust' will be unavoidable. If Democrats move to the Right, utilities will receive scant attention. Supreme Court will probably receive Beaver Valley Water Company case, an appeal from a temporary rate reduction by Pennsylvania Commission based on original cost appraisal of utility property. This may not be a clear cut re-examination of old classic quarrel between reproduction cost theory and original cost theory. Important step might be taken by court upholding original cost for "temporary rate making," distinguished from more permanent variety of rate making, which would be an important step. In regulatory field, important action is likely from SEC's administration of Holding Co. Act. So far, SEC has moved cautiously, and has no disposition to be unreasonably drastic in administering this law. Caustic attacks and maneuvers by prominent proponents of public ownership for public utilities savor of desperate last quarter forward passes. Under New Deal public ownership has made spectacular gains; however it falls far short of a socialized American utility industry. Last quarter of New Deal offensive is at hand—maybe municipal ownership virtually bereft of PWA subsidization in 1939. During election year, Congress will hesitate, before boosting the $45,000,000,000 national debt limit. Summation, continuation of attacks upon private industry by extreme public ownership champions; more reasonable attitude toward private industry by practical administration officials, no new proposals for Federal projects in this direction, excepting another St. Lawrence seaway treaty and a publicly controlled grid system; in general, private industry should gain during the year—reason, return of public sentiment for private industry to continue as the predominating method for rendering this type of service in U. S.—*Samuel A. Evans.*

Charles Juba v. Scranton-Spring Brook Water Service Co. PENNSYLVANIA PUBLIC UTILITY COMMISSION. ORDER OF COMMISSION. Pub. Util. Fort. **31:** 35 (Jan. 4, '40). Proceeding instituted by Charles Juba to require Water Company to extend its distribution system 2,100 ft. to serve complainant and 21 other prospective customers. Complainant avers residents not now served with water by respondent and that residents are compelled to secure water from wells and springs, creating unsanitary and unhealthy conditions; that respondent could readily extend its lines and at moderate cost. Respondent held no knowledge of unsanitary and unhealthy conditions, no fire hazard exists, number of prospective customers 13 not 22, would encounter unusual construction difficulties, extension cost $7,114 estimated annual revenue $154, resultant "gross rate of return" 2.17% without any deductions for depreciation, maintainance, or other operating expenses from the estimated revenue. Record shows 20 properties in proposed service area, 13 immediate consumers, present water supply open public well, unavailable in summer account muddiness and brackishness, fire service limited to one hydrant. Testimony establishes residents can secure water only under physically inconvenient conditions, potentially unsanitary, fire hazard exists on account of distance from hydrant, extension not immediately profitable, however no confiscation of property shown by respondent. Extension sought by complainant is ordered and respondent required to serve any part where such service can be reasonably performed. The fact that service may not initially pay its own

way is no basis for a refusal to serve. A public service corporation may not "pick and choose" only presently profitable territory. If the entire service produces a fair return on the investment, utility is required to serve unprofitable portion.—*Samuel A. Evans.*

On Watching Your Cash Register. D. R. TAYLOR. W. W. & Sew. **86:** 325 (Sep. '39). *Part 1.* An evaluation of the economic limits of meter maintenance. Balance must be struck between repairs and replacements, in terms of dollars and cents. At Roanoke, Va. a planned program for meter inspection and maintenance was begun, involving testing of meters every 7 yrs. "Rotameter" is used for testing. Consumption rates have been studied in detail. The author finds that usually very little flow takes place at low rates hence inaccuracies at low rates are relatively unimportant. The weighted efficiency of meters one year old was found to be 98% and of meters 7 yrs. old—96.9%. Treatment of water to prevent corrosion has improved meter registration. Old types of meters are found less accurate than new modern ones. *Ibid.* **86:** 386 (Oct. '39). *Part 2.* Specifications for meter registration accuracy for used meters are given. Three rates are tested on ⅝- and ¾-in. meters. Accuracy must fall between 98 and 100.5 per cent for rates tested (Roanoke, Va.) Relation between weighted average registration and length of service is shown graphically. From this the loss of revenue through under-registration is calculated. Based on meter repair experience, the cost of repair was also related to length of service. Both these figures rise gradually. Difference between the figures, divided by the years service gives average net loss per meter per year.

Economic Limit of Meter Maintenance

NO. OF YRS. SERVICE	CUMULATIVE LOSS OF REVENUE	METER REPAIR COST	AV. NET LOSS PER YR. PER METER
5	$1.896		
6	2.412	$2.12	$0.049
7	2.976	2.23	0.106
8	3.588	2.34	0.156
10	4.956	2.58	0.238

Based on the table above, Roanoke decided to utilize a 7 yr. meter repair cycle. Writer feels that a similar analysis, based on local experience, could be applied to any water works. Included in meter repair cost are: removal and replacement of meter, drayage, repair labor and materials and 10% overhead charge. If meters were repaired to meet A. W. W. A. specifications for registration, economic repair cycle would be 12 yrs. Writer feels that repair should be more frequent than this. Meter shop reports and their use are discussed. Oil enclosed gear trains are preferred. *Ibid.* **86:** 452 (Nov. '39). *Part 3.* A portable meter testing rig is used for annual field testing of compound and fire meters. Large disc meters are tested and reconditioned at three year intervals. Careful comparative records of registration are kept

for large meters and any registration decrease results in immediate attention to meter. Meter department personnel organization is given.—*H. E. Hudson, Jr.*

ACCOUNTING

The Controller's Job—What Is It and Why? FRANCIS J. BRETT. Edison Elec. Inst. Bul. **7:** 517 (Nov. '39). The Controller's Institute of America lists 17 items as controller's specific duties. (1) Installation and supervision of all accounting records. (2) Preparation and interpretation of financial statements and reports. (3) Continuous audit of all accounts and records. (4) Compilation of production costs. (5) Compilation of distribution costs. (6) Taking and costing of inventories. (7) Preparation and filing of tax returns, supervision of all matters pertaining to taxes. (8) Preparation and interpretation of statistical records and reports. (9) As budget director, preparation of budget, veto of unbudgeted commitments or expenditures regulated by directors' rulings. (10) Determination of adequacy of property insurance. (11) Initiation, preparation, and issuance of standard practices relating to all accounting matters, coordination of systems, clerical, office methods, records, reports, and procedures. (12) Keeping of adequate records of authorized appropriations and sums expended pursuant thereto. (13) Ascertainment that financial transactions are properly executed and recorded. (14) Keeping of adequate records of all contracts and cases. (15) Approving for payment all negotiable instruments as required by directors. (16) Ascertaining if withdrawal of all warrants and securities conform to bylaws and established regulations. (17) Preparation or approval of all regulations to secure compliance with orders of governmental agencies. Controller is chief accounting officer, must have technical qualifications required, understand human nature, be able to appraise individual character, integrity, capacity, ambition, perseverance, thus producing an efficient, competent organization. Vigilance is required to see that efficiency is maintained. Those hiring must regard that as their most important duty. A new employee must measure up to proper standards, good new material making a good organization. Controller, part of the management, head of major department, must with other executive officers, keep the trend of public opinion on the upgrade, regain public confidence, acquire more and hold it. Controller must have pride in his company, believe in it, visualize its future.—*Samuel A. Evans.*

Benefits of Sound Depreciation Practices. ASEL R. COLBERT. Edison Elec. Inst. Bul. **7:** 549 (Nov. '39). Depreciation systems advocated by sinking fundists, retirement-reservists and straight-line adherents. Real progress has been made in dealing with depreciation of recent origin. Accounting requirements adopted by National Association of Railroad and Utility Commissioners in 1922, prescribed by majority of State Commissions are in general use throughout country. No specific requirements were made. Retirement-expense and retirement-reserve accounts were provided. Retirement expense was discretionary with management. Numerous methods of recording retirement expense prevailed on basis of lump sum appropriations, combined per-

centage of revenue for retirement and maintenance, or amount of product sold. Retirement-reserve method became unsatisfactory, depreciation expense and reserves for tax purposes exceeded book amounts. Many utilities changed from retirement-reserve method to depreciation accounting. Consumption of property should be charged to expense currently. Recording of full depreciation expense charge will establish the following benefits. Investors will have better capital protection; additional capital requirements will be more readily obtainable and at lower cost; reduction of funded debt will be facilitated; investment returns will be more stable; value of common stock equities will be enhanced; rate reduction will be facilitated. Adequate provision for depreciation results in likelihood of better financial condition, better control over operating and capital costs, better capacity to purchase materials in favorable market, better preparation for adoption of technical improvements as they develop. Depreciation accounting is more advantageous in maintenance of high grade service and makes lower rates possible than retirement-reserve method. Frank and honest conduct is required from representatives of commissions and utilities. Cooperation between the two is required. Not a "rubber stamp" commission or utility accepting all commission rulings, but impartial consideration of all material facts is necessary. —*Samuel A. Evans.*

Depreciation for Electric, Water, and Gas Utilities. WILLIAM RATTRAY. J. Accountancy. **68:** 253 (Oct. '39). Industrial and mercantile term "reserve for depreciation" is a provision or appropriation created out of earnings during the service life of fixed assets being depreciated; is a valuation reserve which, when deducted from fixed assets, will give at a given date theoretical value of such assets. Utility depreciation term "reserve for renewals and retirements" is reserve or appropriation out of earnings for losses or expense on retirement or replacement of property, on the theory that no losses are incurred until property is actually retired or replaced; not deemed to be a valuation reserve. Retirement method of depreciation measurement is an accumulation for retirements rather than a reserve for depreciation; usually accomplished by applying a certain percentage of gross revenue, deducting actual maintenance, charging the balance as retirement expense, and crediting a like amount to the reserve. Rate usually prescribed for water companies is 9%, in some instances 10%. Retirement method is opposed principally because not actual depreciation, but rather a provision for retirement expense or loss; also claimed to be one of financial expediency and could only accidently represent current consumption of property. Advocates claim method is not intended to measure service life of property, which must be kept in 100% efficient condition at all times. Straight line depreciation method is prescribed by some utility commissions, required by Bureau of Internal Revenue for income tax purposes. Author shows the difference between theory of depreciation and theory of renewals and retirements, that to fill varying requirements provisions may have to be made by a utility co. under both theories; regulatory bodies differ from state to state as to rates and methods; court opinions conflict; and leading accounting firms vary in considerable degree in reporting on matter.—*Martin E. Flentje.*

Organization for the Maintenance of Continuing Property Records. WILL A. CLADER. Edison Elec. Inst. Bul. 7: 543 (Nov. '39). Utility plant records, recently termed continuing property records require careful studying and thinking. Governmental regulation is here to stay, cooperation and understanding is essential between regulatory bodies and utilities. Certain commissions in 1933 required maintenance of perpetual inventories. The problem now is to determine a current working plan. Some companies had valuation department which now maintains all new property records, independent of other departments. Others organized new bureau in accounting department. Some have their engineering or operating department maintain basic property records. Still other companies created new independent property records department. The question is whether record keeping is function of accounting or engineering. Continuing property records should conform to fixed capital accounts. Accounting is defined as "an act or system of making up or stating accounts; a statement of accounts, or the debits and credits in financial transactions." Probably an accountant is reviewer of records for regulatory bodies. Accounting department is dependent upon other departments for work orders but responsibility lies in the accounting department. Accounting for costs of property changes are kept by accounting officer. Certain basic principles are fundamental in operation of records, possible and desirable for forms suitable for large and small companies. Information is then of uniform nature for commissions. Some believe cost of maintaining continuous property records excessive, and that simplicity is required. Cost is from $0.22 to $0.50 per $1,000 of plant investment. Specific property accounting requirement is hardest problem encountered by accounting and engineering statistics. Cooperation is essential between engineering and accounting, as maintenance of property records is combination-engineering job. Quantity and cost records should be kept under supervision of a fixed capital accountant, with practical knowledge of physical characteristics of property, with some engineering and construction experience. Maps, records, sketches maintained in engineering department, financial records in new division of accounting department.—*Samuel A. Evans.*

An Engineer's Comments on the Control of Continuing Property Records. H. R. MARTZ. Edison Elec. Inst. Bul. 7: 545 (Nov. '39). Basic problem is to relate dollars to physical property and maintain relation. This is difficult, due to changing aspect of physical property and allocation of charges between operation, maintainance and construction. It is necessary to establish a schedule of physical property as part of operating records, outside plant most difficult to control. There are three features: map of outside property carrying cross references to job orders by engineering department; fixed capital ledger showing cost of property by accounting department; job order procedure, prescribing rules for recording of construction, retirement and maintenance activities carried out by operations department, key to control over records of property and investment therein. Job order procedure provides such information, facilitating the policy defined as to retirement in connection with replacements of items of property. Each job required preliminary engineering, cost estimate required of construction assemblies installed or re-

tired in form of construction schedule and cost statement. Schedule serves after completion of work as inventory of job output and its cost. Work instruction form furnishes information for approval to perform work, accountant notice to receive charges, and notice to foreman to proceed with job. Engineering records are revised. Running inventory summaries of continuing property record units are revised by some engineers. Same method is used in determining job cost as in original cost construction and retirement costs listed on construction or retirement schedule and cost statement form, prepared with each job. Job cost determination involves proof of ledger balance, application of overheads, and relation of job cost to construction assemblies. Job cost determination procedure is utilized for cost and inventory of property. It also provides for elimination of errors with minimum effort by means of proof of ledger balances. Additions and retirements posted to fixed capital ledger. Responsibility does not rest with any one department, but is one of management.—*Samuel A. Evans.*

DISTRIBUTION—MAINS, VALVES AND RESERVOIRS

The Laying and Jointing of Spigot and Socket Pipes. W. H. E. Surveyor. (Br.) **96:** 363 (Oct. 27, '39). The majority of pipes now laid are of spigot and socket variety. The impression that direction of flow must be into the socket to avoid obstruction if the pipes are not concentric is not based on valid reason. Practice is to lay pipes with sockets uphill because of greater ease in laying and jointing.—*H. E. Babbitt.*

Hydrant Inspection and Flushing. Stuart M. Weaver. Am. City. **54:** 6: 102 (Jun. '39). As a result of many years experience, methods of inspection and flushing hydrants which work efficiently have been developed in Montclair, N. J. All work of this kind is done at night and a definite order of testing is prescribed so that no step will be omitted and each step will check previous ones. Detailed instructions in their order of sequence are given.—*Arthur P. Miller.*

Spheroid Water Tank Built in Brookline. Anon. Am. City. **54:** 11: 53 (Nov. '39). In Oct. 1939, a new 1.6 mg. steel, spheroid water storage tank was completed at Brookline, Mass. Tnis tank is 90′ in dia. and 47′ high and differs from the usual type of Hortonsphere because the bottom is flat instead of curved as it is when such a tank is designed to withstand higher internal pressure. A local ordinance restricted height of structures in the area selected for the new tank and, therefore, it is set on low foundations giving it the appearance of resting on the ground. All metal plates were subjected to a phosphoric acid pickling process and given a coat of special paint by the manufacturer. This process permits the immediate painting of the tank after erection and reduces maintenance costs because the first coat of paint adheres better. The structure was welded.—*Arthur P. Miller.*

Pipe Laying Record at Little Rock. Anon. Eng. News-Rec. **123:** 771 (Dec. 7, '39). Line of 6″ asbestos-cement pipe, 9,400′ long, was recently laid from

Little Rock, Ark., to cavalry camp in 9 days. Route had been selected and levels run the day prior to commencing work. Trench was 2′ deep. Pipe was laid from both ends. Pipe was in 13′ lengths and joints consisted of sleeve couplings and solid rubber ring gaskets. With this type of joint deflections up to 15° can be made without endangering watertightness. Main was flushed until chloramine residual of city water appeared at end of line. Capacity of main is 160,000 gal. per day and highest pressure will be 60 lb. per sq. in.—*R. E. Thompson.*

High Distribution Tank of Large Capacity. ALEXANDER POTTER AND M. H. KLEGERMAN. Eng. News-Rec. **123:** 700 (Nov. 23, '39). Tank completed in July in Batavia, N. Y., is 103′ in diam. and 169′ high to high-water line. Water depth is 25′ and capacity 1.5 mil. gal. There are apparently only 22 tanks with tower height of 100′ or higher and capacity of 1 m.g. or more in U. S. List of these tanks is included. Batavia tank ranks first in order of total height in structures of equal or greater capacity and second in order of tower height among all tanks recorded. Formations underlying site were explored by 32 core borings and 4 test pits. Levels taken prior to filling and 12 hrs. after filling indicated max. settlement (on 1 footing) to be 0.02′. Settlement on other footings ranged from zero to 0.015′. Water levels are transmitted electrically to recording gage in pumping station 1½ mi. distant. Details of tank and tower design and of paints used are given. Final coat, interior and exterior, was of aluminum paint. Total cost was $143,761. Items were: tank and tower $124,700, foundations $18,261 and water level transmitter $800.—*R. E. Thompson.*

New Bending Method for Overland Pipe Lines. ANON. Eng. Cont. Rec. **52:** 26: 10 (Jun. 28, '39). Relatively new method of bending pipe, known as "wrinkle-bending," has been developed, consisting of heating with oxy-acetylene flame one or more narrow bands at right angles to and extending about half way around pipe and bending to desired curvature. Excellent results have been obtained on 4″ to 22″ pipe. For pipe under 6″ in diam., only 1 blowpipe is required and bending may be done by hand; for larger sizes, 2 blowpipes should be used and bending may be performed with tractor, A-frame or bending rig. In general, max. deflection should be 5–7°: greater curvature is obtained by using more wrinkles, spaced at any desired distance apart. Method has found greatest favor in mountainous country. Advantages include absence of thinning of metal at bends, readiness with which bends may be corrected, freedom from stress and low cost. Both light and heavy wall pipe may be bent in this manner and all 3 types of bends (sag, side and overbend) may be readily produced in one section of pipe.—*R. E. Thompson.*

How Water Mains were Lowered at Low Cost. WALTER B. BUSHWAY. W. W. Eng. **92:** 1116 (Aug. 30, '39). Experience recounted in lowering 1500′ of 14″ and 20″ c. i. mains approx. 5′ without interruption of flow in Brookline, Mass. Mains under pressure of 165′, class C pipe, 14″ laid in 1874 and 20″ in '93. Work done by excavating trench to bottom of mains and wide enough to allow 3′ margin outside for elbow room, together with 40′ additional at each end.

Pipe lowered by knocking out blocking allowing pipe to fall on to second set of blocks 4″ lower, etc. Cost less than $125, no leaks encountered.—*Martin E. Flentje.*

Difficult Underwater Pipeline. E. B. Myott. Eng. News-Rec. **123:** 746 (Dec. 7, '39). Description of construction of 16″ main across Kennebec R. connecting Bath, Me., distr. system with lake supply on east side of river. Mains laid in 1894 and 1895 were failures and that laid in 1900 is not in good condition owing to joint failures and damage by dragging anchors. Max. depth of river at city is 50′ and width is about ½ mi. Tidal currents range up to 8 m.p.h. and variation in elev. of sand forming river bed is as much as 10′. One bank is ledge rock with irregular surface. Main is 2,670′ long, 2,444′ being under water. About 2,200′ of latter is carried on pile bents and remainder rests on ledge rock. To reduce no. of joints made under water to min., main was laid in sections of not less than 6 pipes, mostly in 12′ lengths. Pipe joined above water has flexible joints of Metropolitan type and that joined under water Usiflex joints. Usiflex pipe, new development used for first time on this undertaking, has joints consisting of rubber gasket, split ring and follower ring bolted to flange provided on bell. Spigot end has same dimensions as Metropolitan-type pipe. Combined use of these 2 types of joints provides flexibility and strength and simplifies installation. Untreated Norway or red pine piles, with min. penetration of 25′, were used for bents. In section laid on rock ledge, each pipe length was supported by piers built (after jointing and securely blocking) of assembly of burlap bags of 1-cu.ft. capacity half-filled with dry concrete consisting of 1 part high early-strength cement and 3½ parts sand and gravel. Wrought iron pins 1″ in diam. and 4′ long were set in holes drilled 2′ into rock to hold piers in place where rock surface was steep. Pipe was anchored to rock by chains, provided with turnbuckles, between clamps on pipe and eyebolts set into rock. Bolts for Usiflex joints were made of Ihrigize steel, i.e., standard steel at low sulfur content impregnated with silicon alloy after fabrication. Specifications required strength test at 250 lb. per sq. in. and then leakage test at 150 lb., leakage not to exceed 1 gal. per linear ft. of joint per day. Prior to strength test, leakage was 1.2 and after it 0.73 gal. per ft. Cost of installation, including engineering, legal and administration expenses, and interest during construction (6 months) was $137,000 or about $50 per linear ft. of main.—*R. E. Thompson.*

Laying a Water Main in a River Bed. Anon. Wtr. and Wtr. Eng. (Br.) **41:** 567 (Dec. '39). 6″ water main was laid on bed of the river Dee at Aboyne, at average depth of about 3′ below water surface and for distance of about 300′. Stanton-Wilson self-adjusting joint was selected to withstand anticipated pressure of 350′ of head. Because of softness of water in region, spun iron pipe lined with cement was selected.—*H. E. Babbitt.*

Restoring Water-Main Capacity. Arthur Taylor. Am. City. **54:** 8: 66 (Aug. '39). By adjusting water chemically so that it neither corrodes nor deposits, capacities of water carrying pipes can be regained. Beverly Hills (Calif.) did this with success—"dissolving" existing tuberculation and organic

growths, then, when clean, gradually applying to the pipes a thin protective coating of calcium carbonate. The facilities needed for following this procedure were few and low in cost as compared with the expense of main replacement and pumping charges.—*Arthur P. Miller.*

Detecting Water Waste by Observing Sewer Flow. D. D. GROSS. W. W. and Sew. **86:** 334 (Sep. '39). Waste detection is particularly important at Denver, Col., due to use of waters for irrigation, and because of legal restrictions. Accurate records of sewage flows are kept continually and gagings of river flow are frequently taken. Existence of these records facilitates location of leakage, water theft, and waste.—*H. E. Hudson, Jr.*

Leaks vs. Tax Payers Dollars. E. A. MERRITHEW. W. W. and Sew. **86:** 346 (Sep. '39). Saugus, Mass., water losses were serious. Pitometer survey and several damp cellars indicated leakage. Upon repair of leak, distribution pressure increased 6 pounds. Numerous other leaks have been eliminated with resultant savings to the municipality.—*H. E. Hudson, Jr.*

Building a Circular Concrete Clear Well. S. P. MATTHEWS. Pub. Wks. **69:** 11: 20 (Nov. '38). Ardmore, Okla., to enlarge storage facilities at filtration plant, built 75′ inside diam. covered concrete tank, part extending 10′ over a lake. Cost to city was $8160. Details of design given.—*Martin E. Flentje.*

Collapsible Tube Cores for Concrete Pipes. ANON. The Engr. (Br.) **167:** 312 (Mar. 10, '39). An interesting system of casting concrete pipes in the ground either in straight lines or on curves, in lengths which may reach 300′ or more without a joint has been applied in Italy by the Societa Anonima Calalizzazioni Acquedotti Fognature. Pipes of any diameter and for a variety of purposes may be cast. The general principle consists of forming core with air-filled tube, around which concrete is poured in trench. When required, joints are made by slipping a short length of piping over end of rubberized inner tube and casting tube into the concrete so that about half the length of tube is embedded in concrete. Projecting end is cast into next length of pipe in similar manner.—*H. E. Babbitt.*

Pipe Lines for Railway Water Service. R. E. DOVE, ET AL. Ry. Eng. and Maint. **34:** 716 (Nov. '38). Due to wide variety of requirements in railroad service, each pipe line project must be studied from many angles to ascertain pipe material and joints best suited. Wood pipe still used to some extent, mostly in gravity lines on the West Coast. Black steel pipe is used for heating systems and temporary lines. Galvanized steel pipe is suggested for exterior piping and interior plumbing. Cast iron pipe is favored for underground supply lines. Genuine wrought iron is suggested for use on storage tanks and for interior piping exposed to corrosive gas. Copper pipe is suggested for small underground supply lines to depots, stockyards, etc., and for corrosive soils and cinders. Asbestos-cement pipe is being tested and consideration is also being given to coated steel and spiral welded pipe.—*R. C. Bardwell.*

TUNNELS AND AQUEDUCTS

Major Problems of Aqueduct Location. JULIAN HINDS. Eng. News-Rec. **121**: 646 (Nov. 24, '38). Details given of considerations on which decisions were based relative to selection of Parker Dam site as point of diversion for Colorado R. project, route of aqueduct, location of pumping plants and storage reservoirs, type of construction, capacities, etc. Of 242 mi. of main aqueduct, 92 mi. is in tunnel and 62.8 mi. is open canal. Aqueduct crosses several faults, including the San Andreas, one of world's most important active earthquake faults. Articulated concrete pressure line was used for all fault crossings where movement was considered possible. District's water right is limited to ultimate annual diversion of 1500 sec.-ft. To allow for inevitable interruptions in flow, aqueduct capacity was set at 1605 sec.-ft. Full aqueduct flow may not be required for 40–50 yrs. Saving by construction for partial capacity did not warrant adoption of this policy in regard to tunnels but in case of pressure pipelines, where double-barreled construction was advisable for other reasons, half ultimate capacity only was provided for, with terminals set for duplicate barrel. Similarly, pumping capacity and distr. facilities are subject to progressive development.—*R. E. Thompson.*

Construction Program and Management. J. L. BURKHOLDER. Eng. News-Rec. **121**: 659 (Nov. 24, '38). Details of construction program and methods used on Colorado R. aqueduct project are given. Prior to actual construction, provision of roads, water, power, etc., on desert was major undertaking. One-third of tunnels and small part of surface work were constructed by district forces. Designs and construction methods were tested in advance by actually building short lengths of each type of structure. Particular attention paid to care and safety of employees.—*R. E. Thompson.*

Driving an Extremely Difficult Tunnel. B. C. LEADBETTER. Eng. News-Rec. **121**: 669 (Nov. 24, '38). During driving of 13.5-mi. San Jacinto tunnel of Colorado R. aqueduct, water inflows ranging up to 15,800 g.p.m. in or near single working face were encountered and water pressures as high as 600 lb. per sq. in. caved in headings or brought down arch. Peak discharge for entire tunnel totaled 40,000 g.p.m. New methods of advance grouting had to be developed and repeated relocation of portions of tunnel was necessary. Methods used in combating difficulties are described.—*R. E. Thompson.*

Governing Factors in Aqueduct Design. D. B. GUMENSKY. Eng. News-Rec. **121**: 653 (Nov. 24, '38). Details given of procedure followed in designing Colorado R. aqueduct and distr. system. Fact that each cent saved per linear ft. of aqueduct was equivalent to total saving of $10,000 necessitated unusual degree of refinement in design. In addition, considerable experimentation was required to determine suitability of various construction materials to very adverse conditions obtaining on desert. Friction losses computed on basis of Manning's formula.—*R. E. Thompson.*

Wholesale Distribution to Member Cities. R. B. DIEMER. Eng. News-Rec. **121**: 680 (Nov. 24, '38). Principal features of initial distr. system for Colorado

R. aqueduct water are 100,000-acre-ft. Cajalco Reservoir, 62-mi. upper feeder from reservoir to higher areas of district with cross laterals to lower areas, and 38,000-acre-ft. Morris Reservoir which district has contracted to purchase from Pasadena. Ultimately, about 250 mi. of large feeder mains will be required. Water will be delivered by gravity in wholesale lots to member cities, which have present population of about 2,000,000. Details of construction of earth dam and dike for Cajalco Reservoir and of upper feeder are described. Latter is made up of welded steel and precast concrete pipe, cast-in-place siphons and concrete-lined pressure tunnels, varying in diam. from 9′ 8″ to 12′ 8″.—*R. E. Thompson.*

Iron Inner Tube Strengthens Conduit. ROBERT L. PRICE. Eng. News-Rec. **121**: 495 (Oct. 20, '38). Water supply of Toledo is derived from Maumee R., being raised some 65′ to pass through filtration plant and then flowing to 5-mil. gal. covered reservoir. From latter, water flows by gravity through 2.5-mi., 72″ concrete conduit to 16-mil. gal. covered reservoir, from which it is pumped into distr. system. Conduit, built in '09, is of plain concrete, circular in cross-section, with walls about 10″ thick, and is sole connection between filter plant and distr. system. Av. depth of cover about 20′. Conduit passes beneath railroad crossing on one of principal streets of city and proposal to construct subway at this point, which would remove 12′ of cover considered essential to balance internal pressure in conduit, necessitated strengthening of latter. Estimated cost of by-pass around subway was excessive and plan was evolved for reinforcement by lining conduit with wrought iron plates for distance of 500′. Access shaft was constructed, opening made in conduit, and 66″ diam. lining installed using No. 8 gage plates, 10′ long and ¼ circumference in width. Welded joints first specified but abandoned in favor of bolted and gasketed construction, 6″ steel channels being used to make up circumferential joints. Space between lining and conduit was filled with cement grout under pressure. High-early-strength and alumina cements were employed to accelerate setting. As supply could not be interrupted, work could be carried on only by dewatering conduit for limited periods during night. This necessitated about 20 shutdowns, and careful routine of dewatering and refilling had to be developed, details of which are included.—*R. E. Thompson.*

The Strengthening and Final Testing of the Pressure Tunnel for the Water Supply of Sydney, N.S.W. SAMUEL THOMAS FARNSWORTH. J. Inst. C.E. (Br.) No. 6, p. 561 (Apr. '39). The tunnel is 10 mi. long and, as originally designed, consisted of a 10′ dia., concrete-lined bore which, on completion and test proved a failure. Remedial measures consisted in concreting in an 8′-3″ dia. mild-steel, bitumen-lined tube, with circumferential lead joints at intervals of 9′ and 12′. Previous to remedying the defects, model tests were made at a scale of 16.1:1. With a flow of 100 m.g.d. (Imp.) the models indicated a Hazen and Williams coefficient of 88. On completion of the work a full-scale test gave a coefficient of 96. As the steel lining is discontinuous at shaft No. 1, electrical bonding was installed to make electrical connection between the lining of the shaft and the tunnel. Work on the tunnel was divided into two sections, the first section being completed in Sept. '35 and the

second in Nov. '37. Each section, on completion, was tested under different heads. The highest head on the first section was 400′ which gave a max. leakage rate of 41.5 g.p. hour (Imp.), a min. of 6.1 g.p. hour and an av., over a period of 49 days, of 25 g.p. hour. In the second section, under a max. head of 315′, leakage varied between 25 and 11 g.p. hour. Throughout the tests the ground water pressure was zero.—*H. E. Babbitt.*

The New Rodio-Dehottay Method of Soil Freezing. M. DAXELHOFER. Génie civil (Fr.) **114:** 115 (Feb. 4, '39); Ann. Lavori Pub. **77:** 549 (May '39). Paper read at conference organized by Zürich Institute of Soil Mechanics. Results of the usual method of brine circulation often leave much to be desired. Dehottay was first to seek to apply liquid carbon dioxide. Eventually, in collaboration with Rodio, the Rodio-Dehottay system was devised and immediately scored its first success at Rome in '37, when by its aid the Ara Pacis was recovered. Its exact position had been determined in '03, but without the consolidation supplied by the freezing, the attempt to excavate it from its position under the Fiano palace would not have been safe. The mining industry has taken up this system and it has been used for the tunnels under the Scheldt at Antwerp and for the Moscow subway. It has just been used successfully at Cassel in the construction of a collecting gallery at a depth of about 8 meters in the water-bearing layer. The apparatus is simple and carbon dioxide is usually available, does not attack the ordinary metals, and is not dangerous provided that ventilation is good. Brine pumping is eliminated; freezing is more rapid and complete and expense is less. A freezing tube 75 mm. in diameter has a capacity of from 500 to 800 frigories per meter per hour; a zone 2.5 meters in diameter can be frozen solid in four days.—*Frank Hannan.*

Pressure Aqueduct to Serve Boston and Vicinity. KARL R. KENNISON. W. W. Eng. **92:** 1100 (Aug. 30, '39). Following comprehensive report to Mass. legislature by Water and Health depts. on needs of Boston's water supply, work has been begun on projects involving practical abandonment of Cochituate system, after 91 yrs. of use, discontinuance of regular use of Sudbury Aqueduct and reserve use only of Sudbury Res. with addition of tunnel to provide sufficient pressure to system to permit cutting out of regular pumping to southern high service at Chestnut Hill. Present project to use $12,000,000 saved from '26 and '27 appropriations for Ware-Swift supply plus 45% grant from U. S. New work consists of construction of pressure aqueduct looking to the ultimate delivery of water from Wachusett Res. to the principal centers of consumption. This aqueduct divided into 6 sections; #1 two miles long and to be of 12½′ diam.; #2, a tunnel by-pass under Sudbury Res. 3 mi. long and 14′ in diam.; numbers 3, 4, 5, & 6 av. a little over 3 mi. each in length and to be 11½′ diam. Section #6 also includes new high level dist. res. on hilltop site in Weston. Cut-and-cover portions of line aggregate 15 mi. in length and are being constructed of pre-cast concrete steel cylinder pipe, 12½′ diam. in 12′ lengths and 11½′ diam. in 16′ lengths. Description and illustrations given of methods of making and laying pipe.—*Martin E. Flentje.*

Making Large Aqueduct Pipe. Anon. Eng. News-Rec. **123**: 286 (Aug. 31, '39). Boston Metropolitan District's new pressure aqueduct (cf. previous abstract) includes 2 mi. of 12¾' pipe, 3 mi. 14' rock tunnel, 12½ mi. 11½' pipe and about ½ mi. 7' pipe. Elaborate pipe-making plant was established near mid-length of line and supplementary casting plant near upstream end. Precast concrete pipe was adopted for economy and tightness. To assure firmly articulated and tight line, joints were required to have metal-to-metal bearing contact and calked fiber-filled lead gaskets. Joints required to fit within tolerance of $\frac{1}{32}''$ on diam., to assure load transfer without throwing undue load on gasket. Rich concrete mix of low water content is giving strength often well above 5000 lb. per sq. in. Sections cured with steam for 2-3 days and with water spray for 12 days. Details included of fabrication of welded steel shell and reinforcing spirals, casting of concrete and laying procedure.—*R. E. Thompson.*

Shaft Sinking on the Delaware Aqueduct. Anon. Eng. News-Rec. **123**: 233 (Aug. 17, '39). To expedite construction of 85-mi. Delaware R. aqueduct from Catskill Mountains to New York City, contracts for sinking 23 of 30 shafts required were awarded in advance of tunnel contracts. These shafts, 314' to 1550' deep, have been completed and tunnel driving is underway. Only 6 shafts are for tunnel driving purposes alone: other 17 will be equipped with control works for various operating purposes. All except 1 are circular in section, 14'-26.5 finished diam. Construction of shaft 2A, one of deepest ever sunk, except for mining purposes, is described, as typical of shaft construction work as whole.—*R. E. Thompson.*

CORROSION AND CORROSION CONTROL

The Corrosion of Lead and Copper Water Pipes in the Soil. C. A. H. Von Wolzogen Kuhr. Water (Netherlands) **23**: 215 (Dec. 15, '39). In spite of 8 yrs. investigation, corrosion of lead and copper piping in soil has not been explained. For that reason more recent studies are given. Since corrosion of metals is an electro-chemical process term "corrosion-element" is used to indicate that metal of the piping is attacked in analogy with well-known "galvanic-elements" theory. For strong action of corrosive element, where soil solution forms the electrolyte, following examples are given: 1. potential difference between the electrodes as high as possible; 2. complete removal of the "polarised" hydrogen at the positive electrode, which is known by name of "depolarization." This hydrogen would otherwise cause equalization of potential difference, which would result in gradual reduction and eventual stopping of current development from piping or soluble electrode. In case of impure iron piping, impurities form cathode and iron the anode of corrosion element. This fulfills second requirement, whereby hydrogen acceptors in the soil—such as free oxygen, ferric-oxide, pyrites, free sulfur or microbiological processes—become active. By binding of cathodic hydrogen by acceptors corrosion proceeds, so that iron corrosion process can take place under aerobic as well as under anaerobic conditions at pH of about 7. This

reasoning can not be extended to lead and copper, because laboratory experimentation similar to those for iron showed lead and copper to be poor hydrogen donators. This is in conformity with place they take in electro-chemical tension series of metals, and explains why negative results were obtained in corrosion medium with a constant pH value of 7. From standpoint of corrosion, behavior of lead and copper can not be compared with iron under same conditions. Theoretically strong corrosion in a neutral medium can occur only when these two metals go into anodic solution, e.g. when cathode of the corrosion element is composed of material placed in higher tension series than two metals mentioned. Only gold, platinum, etc. could act as cathodes in soil, but these metals are not present. In connection herewith experiments in laboratory produced only severe corrosion of lead and copper when elemental carbon (gas coal, retort coal, coke) was added to corrosion medium consisting of soil water or wet sand at a pH of 7. This severe corrosion was comparable to corrosion cases observed in practice. In an earlier publication (Gas en Water, Jan. 9, '31) author called attention to fact that agressive constituent in corrosion of lead in ground mixed with cinders is elementary carbon in form of coke. References in literature cited would indicate that as far as tension series is concerned carbon has same place as platinum. This is in accord with agressive action of carbon on lead and copper found in laboratory experiments. In practice, results obtained when lead or copper piping is placed in contact with cinders are examples.

In connection with laboratory experiments where corrosion failed in media with pH value of 7 unless carbon was added and on basis of theoretical considerations that lead and copper only corrode when a substance higher in tension series is present in the corrosion medium, following question was raised: if carbon is only cause of all unexplained corrosion cases of lead and copper in soil, this carbon must be present around the corroded pipes and also in corrosion products formed. Idea was supported when in all cases carbon was found in soil surrounding the pipes. With ordinary physical, chemical and microbiological examinations often no causes could be established, because presence of aggressive carbon was not considered. Has been found that carbon occurs more frequently in soil than expected. Cinders, coke breeze, coal, fly ash are frequently used for secondary roads and paths and for fill, while factory chimneys, trains and boats spread smoke, cinders and fly ash over country side. Water samples obtained from different rain gages appeared to contain carbon, indicating effect of wind to distribute floating cool particles. Carbon particles found are often so finely divided that chemical determination must be made with aid of microscope. Fine coal particles in moderate quantities mixed with sand can not be seen, while in dark soil even coarser particles escape detection. Result has been that in previous corrosion studies no systematic search has been made for aggressive carbon. Other possible causes of corrosion have been made subject of study. Number of polder soils in which lead and copper piping had been attacked appeared to contain carbon as aggressive substance. Frequently corrosion products, present as crusts on surface of corroded pipes, contained carbon. This may be considered as evidence that attack is caused by carbon. It should be kept in mind that

ordinarily corroded pipes sent in for examination are free from crusts or soil, because they are removed by water escaping through leaks. In such cases soil samples may not represent true conditions. Corroded pipes to be examined should not be cleaned or washed, because soil adhering to pipes or crust formed is most important for determination of carbon. Fact that corrosion of pipes is mostly local indicates that carbon is not evenly distributed throughout soil. This heterogenous mass makes determination more difficult. Strongly corroded lead pipes show pock marks and frequently perforation. Perforation can occur in few months or may require several years. Copper pipes on corrosion show much pitting over entire surface, while perforation again may occur in relatively short time. Difference in appearance must be attributed to size of aggressive carbon particles. Fine coal particles produce porous, and coarser particles rough surface, on pipes. Perforations can be explained by fact that ground pressure causes gradual movement of the coal particle, which is slowly brought into solution electro-chemically, until pipes are penetrated. Appearance of all corroded lead and copper pipes is essentially the same—which again indicates a single cause. It is emphasized that there are only apparent differences between corrosion in soil of iron and lead and copper. Since iron is good hydrogen donator, and, with metalic contact and moist soil, corrodes easily, intensity of the process is determined principally by depolarization of corrosion element. By study of iron corrosion, emphasis is placed on depolarization process caused by presence of hydrogen acceptors of microbiological processes in soil. In case of lead and copper (poor hydrogen donators), although processes are same, emphasis is on aggressive carbon because it changes metals from poor to good hydrogen donators. Experimentally it could be shown that the following conditions are required for corrosion of lead and copper piping: (1) good contact must exist between metal of the pipes and carbon particles; (2) free action of the aerobic or anaerobic process. This means that presence of carbon in soil itself is no cause of corrosion.

Constitution of corrosion products formed depends upon whether process is aerobic or anaerobic. In the primary corrosion reaction:

$$M + 2H_2O \rightarrow M\ (OH)_2 + 2H$$

since $M = 2$ valent (pipes) metal, the formed hydrogen must be bound if corrosion will proceed. This binding is caused by hydrogen acceptors in soil or by microbiological processes. Since lead and copper function only in combination with carbon as good hydrogen donators, corrosion elements in soil are carbon-lead and carbon-copper, so that all cases of lead and copper deterioration in the soil are result of these corrosion elements and their depolarisors. Under aerobic attack lead changes according to primary corrosion reaction into lead hydroxide, $Pb(OH)_2$, which in combination with carbon-dioxide present in soil changes to lead carbonate, $PbCO_3$. Lead ions from anodic soluble lead form with sulfates and chlorides $PbSO_4$ and $PbCO_3$ respectively. These aerobically formed corrosion products are insoluble, white compounds, with frequently pretty salt crystals, visible by hand lens. Under same conditions copper changes to copper hydroxide, which changes to in-

soluble basic copper carbonate of green or blue green color. Under anaerobic conditions frequently occurring sulfate reactions take place:

$$H_2SO_4 + 8\ H \rightarrow H_2S + 4H_2O \text{ (H-acceptor)}$$
$$\text{Lead: } Pb(OH)_2 + H_2S \rightarrow PbS + 2H_2O$$
$$\text{Copper: } Cu(OH)_2 + H_2S \rightarrow CuS + 2H_2O$$

Anaerobically formed corrosion products of lead and copper are insoluble, black sulfides. Aerobic and anaerobic processes can be distinguished by color of corrosion product. Since they are practically neutral reactions both corrosion processes take place in medium with pH value of about 7.

To determine carbons as aggressive elements a method was developed. It must be kept in mind that in addition to the black mineral particles, aerobically formed dark substances such as FeS, FeS_2 (pyrites) and organic materials (peat) are present, making identification more difficult. Since combustion of carbon is important no other combustible should be present, including free sulfur. Method is principally based on destruction of all combustible materials present except carbon. Melting method of determining carbon in sample with potassium hydroxide at temperature of about 180°C, followed by digestion in diluted acid developed by J. de Hek in laboratory of Provincial Water Division of North Holland, is very effective. Black carbon particles contrast sharply with sand covered with white silicic acid. Since corrosion is caused by carbonized coal, isolation of coal as well as carbonized material is important, because it indicates presence of active material. After isolation, identification is as follows: (1) blackness of particles, (2) hardness (difficult to crush, determined by lens or microscope) (3) combustibility (often explosive if heating is accomplished in the presence of $KClO_3$, and KNO_3, while glowing may be observed in darkness) (4) presence of CO_2 formed by burning, (5) microchemical (melting with KNO_3, mass extracted with water; water extract with strontium acetate produces S_2CO_3, showing several specific crystals).

Presence of carbon on pipe surface is determined by brushing pipe with steel brush and heating material with dilute HNO_3, leaving carbon as a black mass. Iron in contact with carbon in soil shows severe corrosion. With aid of method aggressive carbon was widely found in soil, leading to the conclusion that rate of iron corrosion in soil is aided by carbon. Role of carbon has been missing link to explain severe corrosion in soil. It is not likely that other substances have the same effect.—*Willem Rudolfs.*

Protection Against Corrosion in Warm Water Systems. OTTO KROHNKE. Gas-u.Wasser. **82**: 641, 653. (Sept. 9-16, '39.) Use of copper and lead tubing in water distribution systems is prohibited in Germany. This caused a search for other materials resistant to corrosion. Pure aluminum was found resistant to most water even when hot. Aluminum alloys show more corrosium. Alminum cannot be used in combination with other metals as electrolytic effects occur at contact. Internal protective coatings of pipes have been developed, but fully continuous application is difficult. To conserve available copper, copper plating of tanks up to 0.5 mm. thickness is used and special pipe of thin copper, wound for reinforcement with hard paper (Kupremarohr) finds

wide application. Pipes of special hard porcelain, glazed inside and outside, with bell and spigot or screw connections were found to be serviceable in many cases. Also special glass pipes in use, as well as pipes made from Mipolam or Ingelite (polymer resins). All of these materials require special fittings and specially trained labor for installation. On interior coatings those with enamel, lacquers, zinc or phosphates are in use. Chemical treatment of water must not only be controlled at plant, but also in hot water system by use of easily changeable control pieces of old and new pipe inserted in horizontal section close to heater. These are checked after 6 months of service and thereafter at intervals of not over 1 year. Chemical processes for avoidance of corrosion include elimination of oxygen by use of sodium sulfite, formation of protective coatings with phosphates or by use of magno-filter. Structural and operating measures can reduce corrosion, such as use of uniform material to avoid electrolytic effects, avoidance of overheating (60°C. is given as limit). High pressure seems to increase danger from corrosion, whereas electrical currents and chlorination seem to have little influence. Extensive bibliography is attached.—*Max Suter.*

The Treatment of Aggressive Waters. G. BATTA AND E. LECLERC. Rev. universelle mines **15**: 445 ('39). Belgian methods used for treating water to eliminate corrosion in water-distributing systems are described. Aeration not very satisfactory for soft waters as the CO_2 content cannot be lowered to less than 5-7 mg./liter, which still leads to corrosion. Treatment with lime and soda, properly applied, gives complete neutralization; the equil. bicarbonates-free CO_2 is disturbed and a ppt. of a carbonate or hydroxide of alk. earths is formed which protects the metal. Filters of marble or calcite or calcined magnesia neutralize water sufficiently but an over-alky. of the filtered water must be avoided. Filtration through "Magno," a calcined dolomite of 71% $CaCO_3$, 3% $MgCO_3$, 22% MgO and 4% not defined residue, has advantage of accelerated velocity of reaction with acid constituents of water and is sufficiently alk. to form protective deposition on the metal.—*C. A.*

The Cathodic Behavior of Zinc Versus Iron in Hot Tap Water. GERHARD SCHIKORR. Trans. Electrochem. Soc. 76, 9 pp. (preprint) ('39). Tests on galvanized steel pipe were conducted which showed that Zn in coating behaved as cathode when submerged in hot tap water. This cathodic behavior of Zn could, in general, be definitely established only at temp. above about 70°. Exptl. results tend to clarify no. of apparently unusual corrosion phenomena observed in practice with galvanized pipe used in hot-water service.—*C. A.*

Study of the Equilibrium $CaCO_3$-CO_2-H_2O; Theory of Soft Waters. J. FRANQUIN AND P. MARÉCAUX. Chim. et Industr. **40**: 1224 ('38). *Read at 18th Congress of industrial chemistry, Nancy.* Authors accept, contrary to Tillmans's theory, the perfect thermal stability of the bicarbonate ion and consider that the system $CaCO_3$-CO_2-H_2O is governed by slight solubility of calcium carbonate. They give explanation of carbon dioxide of equilibrium and show that it only exists when there is certain concentration of calcium bicarbonate, i.e. 5.1×10^{-4} mol. Inversely solution of calcium bicarbonate

of concentration below 5.1×10^{-4} M is stable at ordinary temperatures. These findings are used to explain aggressive action of soft waters.—*W. P. R.*

Internal Protection of Water Mains by Means of Asphaltic Bitumen Compositions. J. P. Pfeiffer and Gobel. IIe Congr. mondial petrol **3**: Sect. 3: 80 ('37) (in English). Bituminous linings for water mains are discussed from standpoint of compn. and properties. Satisfactory coating complies with following specifications: m.p. 100–130°, penetration at 25° 25–10, flow in a 5-mm. layer (at 70° and at slope of 45° after 20 hrs.) less than 1 mm., shatter test at 0° 44.8 grams, at 15° 357.5 grams, and max. filler content of 30%. Several powdery materials, kieselguhr, clay and gypsum are not acceptable as fillers for this application. Economics of lining mains are considered from viewpoint of loss in discharge capacity of lines due to corrosion of unprotected pipes. Data on discharge capacity with and without protective coatings are given.—*C. A.*

Reconditioning Steel Pipe Lines. B. L. Hamilton. Surveyor (Br.) **95**: 541 (Apr. 21, '39). *Extract from Commonwealth Engineer.* Gives account of reconditioning of Waitakere pipe line in Auckland, N. Z. Line consisted of 7½ mi. 24″ and 6 mi. of 27″ steel pipe 30 yrs. old. Pipe was found in fairly good condition where soil of neutral character was well packed around the bottom half, but where such soil was moist corrosion had taken place in form of grooves. Where soil had not been well packed, coating had blistered and damp, white powder was found which turned rusty on exposure to air. Where bottom half was fully exposed to air it was scaly and badly corroded. Found that the yarn in most of lead joints had rotted away so that in jointing new pipes clay was used, to hold lead, after which clay was removed. Old pipes were removed from trench, taken to a reconditioning plant, 7″ were cut from spigot end, 2″ from socket end, pipes were cleaned by rapidly revolving a chain inside of them, defects were spot welded, new socket was welded on, two lengths were welded together, pipes were tar dipped and coated with hessian, and after static test of 250 lb. per sq.in. were relaid in trench.—*H. E. Babbitt.*

Problems of Corrosion and Selection of Materials for Warm Water Conduits and Heating Plants. L. W. Haase. Gesundheits-Ing. **62**: 86 (Feb. 18, '39). Lack of copper in Germany has resulted in use of iron for water heaters. This requires treatment of water to avoid corrosion. Danger points in installation are described. Whereas chemical composition plays great rôle in corrosion with cold water, dissolved oxygen is important with hot water. Improved deoxygenation processes are mentioned as well as use of small amounts of phosphates to build up protective layers in pipes. Electrolytical processes tend to reduce amount of dissolved iron. On other hand, filters composed of Magno-mass not only make water more alkaline, but also eliminate particles from aggressive waters that tend to form local elements in pipes which are cause of local corrosion. Naturally corrosion can be avoided if pipes of non-metallic materials are used. Covering of iron pipes with resins is only partially successful. Plating with stainless steel is better. In heating boilers corrosion can be checked by addition of chromic acid to the make up water.—*Max Suter.*

Determination of the Corrosive Power of a Soft Water. M. VERAIN AND J. FRANQUIN. Chim. et Industr. **40:** 1224 ('38). *Read at 18th Congress of industrial chemistry, Nancy.* In determination of alkalinity in water by titration with an acid a conductimetric method is now used. Total carbon dioxide is determined by means of Van Slyke and Neill's apparatus. From alkalinity and content of total carbon dioxide, content of free carbon dioxide can be calculated; this is divided into aggressive carbon dioxide and carbon dioxide of equilibrium; aggressive carbon dioxide is determined by marble test, taking pH value into consideration. "Initial speed of attack of marble" was studied. This was done by meosuring conductivity after water had been in contact with known quantity of marble for certain length of time. Authors' determinations enabled them to classify the different waters.—*W. P. R.*

Causes of Corrosion in Water Mains. T. KIELANOWSKI. Gaz i Woda (Poland) **18:** 269 ('38). External corrosion is slow when whole main is corroding, but fast when corrosion is localized; this is attributed to galvanic action caused by presence of "local elements", metal-metal oxide, or metal-soil contact. Graphitization (formation of soft cuttable substance composed of graphite, Fe oxide and cementite) is caused by stray currents, but requires presence of O. Compn. of the metal is less significant than type of soil, though no definite conclusions could be drawn as to effect of H-ion concn., salts in soil or cond. of soil on corrodibility. Clay soils are more corrosive than sandy soils, and presence of Ca exerts protective action. Corrosion does not take place without presence of water and sometimes O is necessary.—*C. A.*

Recent Developments with Koroseal. F. K. SCHOENFELD, A. W. BROWNE, JR., AND S. L. BROUS. Ind. Eng. Chem. **31:** 964 (Aug. '39). Among other uses, "Koroseal", an elastic product prepared by polymerizing vinyl chloride, is suitable for covering pipe lines for protection against soil corrosion.—*Selma Gottlieb.*

CHEMISTRY

Potentiometric Method for the Accurate Measurement of Hydrogen-Ion Activity. WALTER J. HAMER AND S. F. ACREE. Jl. of Res., Nat'l. Bureau of Standards, U. S. Dept. of Commerce. **23:** 647 (Dec. '39). A potentiometric method is described for measurements of hydrogen-ion activities in aqueous solutions. Galvanic cells without liquid junctions are used. Hydrogen and silver-silver chloride electrodes are placed in solutions to which known amounts of either sodium or potassium chloride have been added. Detailed description is given of the equipment and experimental procedures which are necessary for precise measurements of hydrogen-ion activities. Electromotive force of galvanic cell, on the average, is reproducible to 0.02 mv. which is equivalent to 0.0003 pH unit. It is found that the electrodes function reversibly and exhibit no aging, hysteresis, or polarization effects. It is shown how hydrogen-ion activity may be calculated from electromotive force by thermodynamic methods, using the Nernst equation, in which concepts of activity and interionic attraction are incorporated.—*Anon.*

Notes on the pH Measurement of Natural Waters. RUSTICO TENGCO. Wtr. and Wtr. Eng. (Br.) **41**: 507 (Oct. '39). Unless isohydric technic of pH determination by colorimetric method is used, indicator solution will affect original pH value of a very dilute or weakly buffered solution. In colorimetric measurement of Manila water supply error due to "indicator and salt effects" is probably most significant when procedure of Clark is followed. Adjustment of indicator solutions for ordinary colorimetric pH measurements in natural waters is not as necessary as has been claimed by some workers.—*H. E. Babbitt.*

Hydrogen-Ion Activity and Buffer Capacity of Natural and Treated Waters. A. P. BLACK AND EDWARD BARTOW. Ind. Eng. Chem. Anal. Ed. **11**: 261 (May '39). Detn. of pH with quinhydrone (QH) electrode appears simple but certain limitations and errors must be noted. Contrary to results previously reported, QH satisfactory for electrometric work can be prepd. by Biilmann's ferric alum method. However, purity of QH is very important, especially with weakly buffered solns. such as natural waters. Use of standard buffer mixtures as electrode solns. allows prepn. of "isohydric" reference electrodes of any desired potential. pH values obtd. with QH electrode were consistently lower than isohydric colorimetric values corrected for "salt effect", possibly due to specific action of normal carbonates on QH electrode. For accuracy of 0.1 pH unit QH electrode may be used with waters of fairly high alkalinity (approx. 300 p.p.m.) up to pH 7.5, but for like accuracy is not suitable for waters of low alkalinity (below 100 p.p.m.) much above pH 7.0. When alkalinities were expressed as moles of $CaCO_3$ per liter, buffering action of 105 natural and treated waters of many types in all cases equalled or exceeded that of the corresponding buffer of like molar concn.—*Selma Gottlieb.*

Hardness in Water and Its Determination. P. HERRMANN. Chemikerztg **63**: 336 ('39). Determination of carbonate hardness in water by titration with $N/10$ hydrochloric acid, using methyl orange as indicator, gives erroneous results if alkali bicarbonates are present; figures for non-carbonate hardness, found by deducting the carbonate hardness from total hardness, would also be erroneous. Many samples of ground water from central and northern Germany contained considerable amounts of bicarbonate. In analyzing waters of this type, determinations should be made of combined ("bound") carbon dioxide by titration with $N/10$ acid using methyl orange as indicator, total hardness by gravimetric method or by Blacher's method, and permanent hardness remaining after prolonged boiling, by neutralization with $N/10$ acid and titration with potassium palmitate. The difference between total and permanent hardness gives the temporary hardness of the water. The difference between total bound carbon dioxide and amount of carbon dioxide corresponding to temporary hardness is multiplied by 3.82 to give sodium bicarbonate content of water in mg. per liter, when all determinations are made with 100 c.c. samples. Examples of calculations are given.—*W. P. R.*

The Solubility of Calcium Bicarbonate. STEPHEN S. HUBARD. J. Phys. Chem. **42**: 971 ('38). Soln. of $Ca(OH)_2$, treated for several hrs. with CO_2,

was placed in collodion bag and immersed in distd. water. Of 26.8 mg. Ca, calcd. as hydroxide, placed in bag, 20.4 mg. was found by titration in diffusate after overnight period and 6.2 mg. in residue. Diffusate, examd. with Tyndall beam, was optically empty. Evapn. of portion gave residue which effervesced upon acidifying with HCl. Results are interpreted to confirm common assumption that true soln. of Ca bicarbonate is formed.—*C. A.*

Apparatus for Determining Carbon Dioxide in Carbonates and in Mineral Waters. R. FRESENIUS AND F. NEUMÜLLER. Z. anal. Chem. **111**: 265 ('38). Apparatus is much more compact than form originally suggested by C. R. Fresenius in 1873 or than most of modifications suggested since then. Small evolution flask is provided with ground glass top which has one opening into condenser above it and another to 3-way stopcock leading to side funnel and to tube for introducing CO_2-free air. Short condenser above flask contains spiral and splash trap and leads to short but efficient drying tube, also through ground glass connection. Drying tube leads to KOH bulb of modern design which has ground glass connections at both ends. Apparatus is sold by Herbig of Darmstadt and patent has been applied for.—*C. A.*

Methods for the Automatic Determination of Alkalinity and Hardness of Water-Vapour Condensates. E. V. KHALAPSINA, L. E. MOVSHITS, AND A. P. MAMET. Zav. Lab. (Moscow) **7**: 784 ('38). Full details including illustrations and descriptions of apparatus are given for periodic and continuous determination of bicarbonate alkalinity and calcium hardness of tap water, boiler feed water and condensate waters. Alkalinity can be determined at 10–18° in photoelectric colorimeter, using 5 ml. of 1% sol. of alizarin red as indicator in 100 ml. of sample. In periodic photonephelometric determination of hardness, Leiman's method as modified by Miloslavskii and Vavilova gives accurate results but takes 50–60 min. for each determination. Potassium oleate can be used for continuous automatic determination of hardness but is unsuitable for low concentrations of calcium.—*W. P. R.*

The Titration of the Total Potassium and Sodium Content of Potable Waters. J. F. REITH AND A. LOOYEN. Pharm. Weekblad **75**: 690 ('38). Titrimetric detn. of alkali metals in water by method of Tillmans and Neu (*C. A.* **26**: 4010) gave irregular results. Systematic study of sources of error led to following suggested procedures. A. (for 5 to 50 mg. Na per detn.): Evap. a 250-cc. sample to dryness in a Pt dish with 10 cc. of 4 N H_2SO_4. Transfer residue to a 300-cc. Erlenmeyer with 200-cc. of H_2O, heat to boiling and add dropwise 5 cc. satd. $Ba(OH)_2$ soln. After testing for complete pptn., add an addnl. 2 cc. of $Ba(OH)_2$. Cool, filter with suction and wash with 20 cc. of H_2O. To filtrate add 2 drops of 1% phenolphthalein soln. and pass in water-washed CO_2 until color disappears. Turbidity may appear at this point. Boil until red color of indicator again becomes visible (10–25 min.) and 30 min. more. Cool and filter as before, rinsing twice with 20 cc. of CO_2-free H_2O. Add 1 cc. of mixed indicator (4 parts 1% bromocresol green in alc., 1 part 1% dimethyl yellow in alc., and 10 parts alc.) and titrate with 0.05 N HCl to pH of 4.50. Color com-

parison is made with a soln. contg. 0.35 cc. of 1% $K_2Cr_2O_7$, 8.0 cc. of 2.5% $CuSO_4 5H_2O$ and H_2O to 250 cc. Table is given of corrections to be applied to the calcd. amt. of alkali metals. B. (for more than 0.5 mg. Na): Procedure is same as A except that period of boiling after indicator color returns is reduced from 30 to 10 min. Then exactly 10 cc. of 0.1 *N* NaOH is added, boiled for 5 min., cooled, filtered and titrated as before. A blank is run to take account of the added alkali. No corrections are applied in this case.—*C. A.*

Determination of Dissolved Oxygen in Aqueous Solutions. G. A. Perley. Ind. Eng. Chem.—Anal. Ed. **11**: 240 (May '39). In Winkler method for detn. of DO sources of error are interfering substances in the water, DO added in the reagents, and limitations of starch-iodide titration endpoint. In power plant boiler water control, to avoid temperature errors, pass hot water through cooling coil before sampling. Collect one 500 ml. and two 250 ml. samples, and add reagents for Winkler DO detn. to 500 ml. sample and one 250 ml. sample. Measure out exactly 250 ml. from treated 250 ml. bottle, add exactly 250 ml. of untreated water and 5 ml. of 0.01 *N* K biiodate and titrate electrometrically with 0.01 *N* $Na_2S_2O_3$. Measure out 500 ml. from treated 500 ml. bottle, add exactly 5 ml. of K biiodate and titrate as before. DO of 250 ml. sample is detd. by diff. between 500 ml. and 250 ml. titrations. For electrometric titration use 1 x 1 cm. Pt sheet for indicator electrode and satd. HgCl-satd. KCl as reference electrode. Both are mounted in 800 ml. beaker and soln. stirred mechanically during titration. Portable potentiometer with 0 to 1100 mv. range is used. Endpoint occurs between 0.290 and 0.260 volt when one drop of 0.01 *N* $Na_2S_2O_3$ soln. causes abrupt drop of over 30 mv. Normal variation of SO_4 and Cl has little influence on endpoint. Diff. in I concn. involves no error. pH is properly controlled by reagent concns. recommended. About 0.0064 p.p.m. of DO can be detd. by this method, starch-iodide and personal equation errors are eliminated and influence of various substances in the water is cancelled out by double titration. Equipment in portable form is illustrated.—*Selma Gottlieb.*

Determination of Dissolved Oxygen. C. C. Ruchhoft, W. Allan Moore and O. R. Placak. Ind. Eng. Chem.—Anal. Ed. **10**: 701 (Dec. '38). Alsterberg modification of Winkler method, using sodium azide to destroy nitrite, was applied as follows: To water sample in standard 300 ml. bottle, 0.7 ml. of concd. H_2SO_4 is added, followed by 0.8 ml. of a 2.0% aqueous soln. of Na azide. Bottle is stoppered, shaken, and allowed to stand 10 min. One ml. of $MnSO_4$ soln. and 3.0 ml. of alkaline KI soln. are added and sample shaken 20 sec. After ppt. settles, sample is acidified with 2.0 ml. of concd. H_2SO_4, and vol. of soln. equivalent to 200 ml. of orig. sample is titrated immediately with 0.025 *N* $Na_2S_2O_3$, using starch indicator. 411 pairs of duplicate samples of Scioto River water were analyzed by above method and by Rideal Stewart modification of Winkler method. Azide gave slightly higher results in nearly all cases, though results checked surprisingly well. Azide method is one step shorter than Rideal Stewart, since it is not necessary to destroy excess azide, is effective in destroying nitrite, and seems less affected by organic matter than is permanganate. It is applicable to D.O. detns. in water from sewage-polluted streams where nitrite is encountered.—*Selma Gottlieb.*